

CHAPTER FOUR: PRESENTATION OF RESULTS

4.1 RESULTS:

This chapter presents the results of the spectrographic analysis of all vowel tokens of the various dialects of Ga and Dangme. In all, twelve vowels, repeated three times, were analyzed for each of the ten speakers of six dialects for a total of 2160 tokens of vowels. The results (i.e. values of the formant frequencies) are presented in two forms: tables and figures (i.e. plotted vowel charts). The tables contain the means and standard deviations of the F1 and F2' (i.e. F2 – F1) values of each vowel in each dialect. (See Appendix 2 for the values for F1, F2, and F2' of all vowel tokens in the various dialects.) As indicated in Chapter 3 of this study, F1 inversely corresponds to vowel height, that is, the lower the F1 value the higher the vowel in the vowel chart. F2 corresponds to backness (and/or rounding); the F2 value decreases towards the back (and rounded vowels).

Scatter plots of the values of F1 and F2' (with F1 on the vertical axis and F2' on the horizontal axis) are first presented in each section of this chapter. F2' rather than F2 was used for all the plots because, as indicated by Ladefoged (1993), there is a better correlation between the degree of backness and F2' than F2. In other words, F1 plotted against F2' gives a better representation of the traditional vowel chart than against F2. As much as possible, spurious formants were excluded from the analysis. In addition, computed means of F1 values are plotted against F2' values on a Bark scale. Ellipses were then drawn for each vowel, using the mean frequency values and their standard deviations. The ellipses were drawn using two standard deviations of the F1 and F2'.

The Ga vowels are presented in Section 4.2 while the Dangme ones appear in Section 4.3. In both cases, the discussion concentrates on the oral vowels which are presented first. This makes it relatively easier to compare Ga/Dangme vowels at a glance with data from other natural languages, which normally concentrate on oral vowels. Data from the nasalized vowels are then compared with the oral ones. Finally, Section 4.4 compares data from both Ga and Dangme. All descriptions of vowels presented in this Chapter are based on the normalized data, taking into consideration, means, standard deviations, as well as levels of significance.

4.2 VOWELS OF THE GA LANGUAGE AREA

The vowels of the Ga language are presented in this Section. Rural Ga (Abokobi) vowels are presented first, followed by Urban Ga (Bukom) vowels, and then Suburban Ga (Teshie) vowels. In each of these Ga dialects, 12 vowels were repeated three times each by 10 speakers (five male and five female) in the same phonetic environments between two bilabial plosives [b] and [p] (in the frame “kεεmɔ b__ pε”). In each case, test words that were not pronounced as they are normally produced by the native speakers were rejected. Similarly, test words that were pronounced with different tones other than the high tone were left out.

4.2.1 Rural Ga (Abokobi) Vowels

The Abokobi vowels were elicited from 10 native speakers between the ages of 30 and 66, who have lived almost all of their lives in Abokobi. All of the speakers have had basic education and can read and write Ga. None of the speakers has had any university education and they are basically traders. The results obtained are presented in Table 4.2.1.1 and Figures 4.2.1.1, 4.2.1.2.

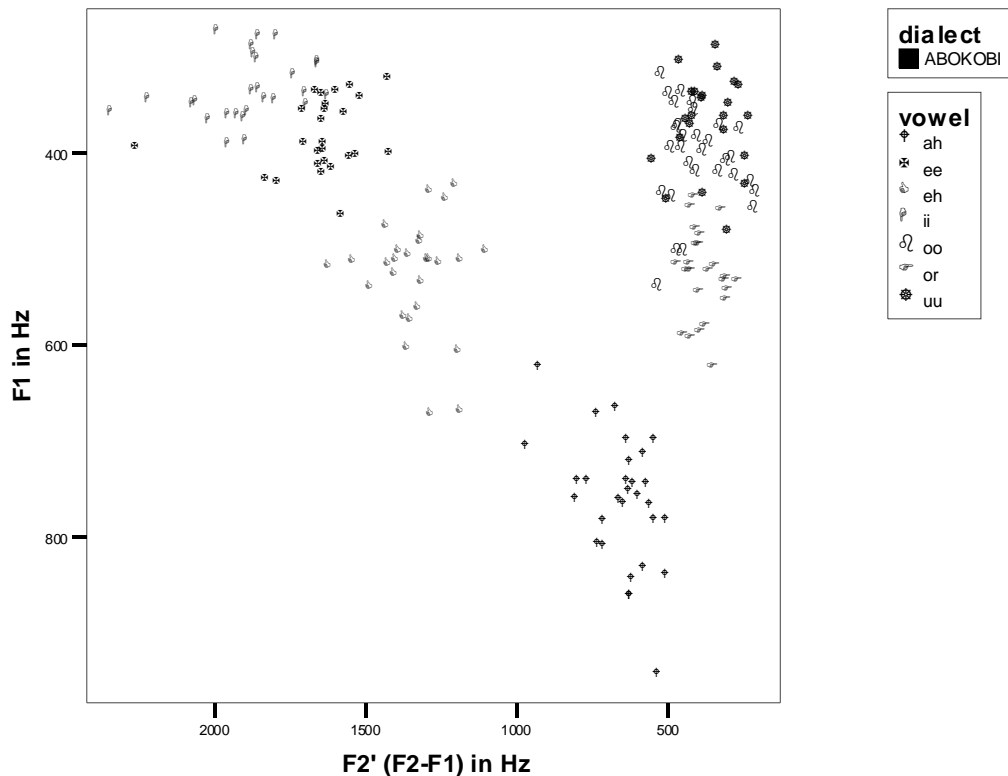


Figure 4.2.1.1 Scatter plot of Abokobi oral vowels.

Figure 4.2.1 is a scatter plot of all tokens of the seven oral vowels of all 10 speakers of Abokobi Ga. The plot shows some slight overlap between /i/ and /e/ on the one hand, and /o/ and /ɔ/ on the other hand. There is also considerable overlap between /o/ and /u/, while tokens of /ɛ/ and /a/ show hardly any overlap.

Table 4.2.1.1 is a summary of the means and standard deviations of the F1 and F2' values of each vowel as uttered by Abokobi speakers. These values are used to plot the points indicated on the Abokobi vowel chart (Figure 4.2.1.2), described below. Fig.4.2.1.2 shows a plot of the oral vowel space of Abokobi dialect of Ga plotted as ellipses.

Table 4.2.1.1 F1 and F2' means and standard deviations of Abokobi formant frequency values.

Dialect		Vowel	i	e	ɛ	a	ɔ	o	u	ĩ	ẽ	ā	õ	ũ
Abokobi	F1	Mean	336	382	536	772	529	405	370	393	562	661	533	399
		Std.dev.	32	38	65	63	45	51	49	86	100	116	74	48
	F2'	Mean	1884	1619	1319	661	382	404	367	1780	1309	567	329	437
		Std.dev.	165	196	128	119	53	96	88	157	158	148	86	78

Results of the statistical analysis indicate that Abokobi Ga has three front vowels, namely, [i], [e], [ɛ]; three back vowels, namely, [u], [o], [ɔ], and a central vowel, [a].

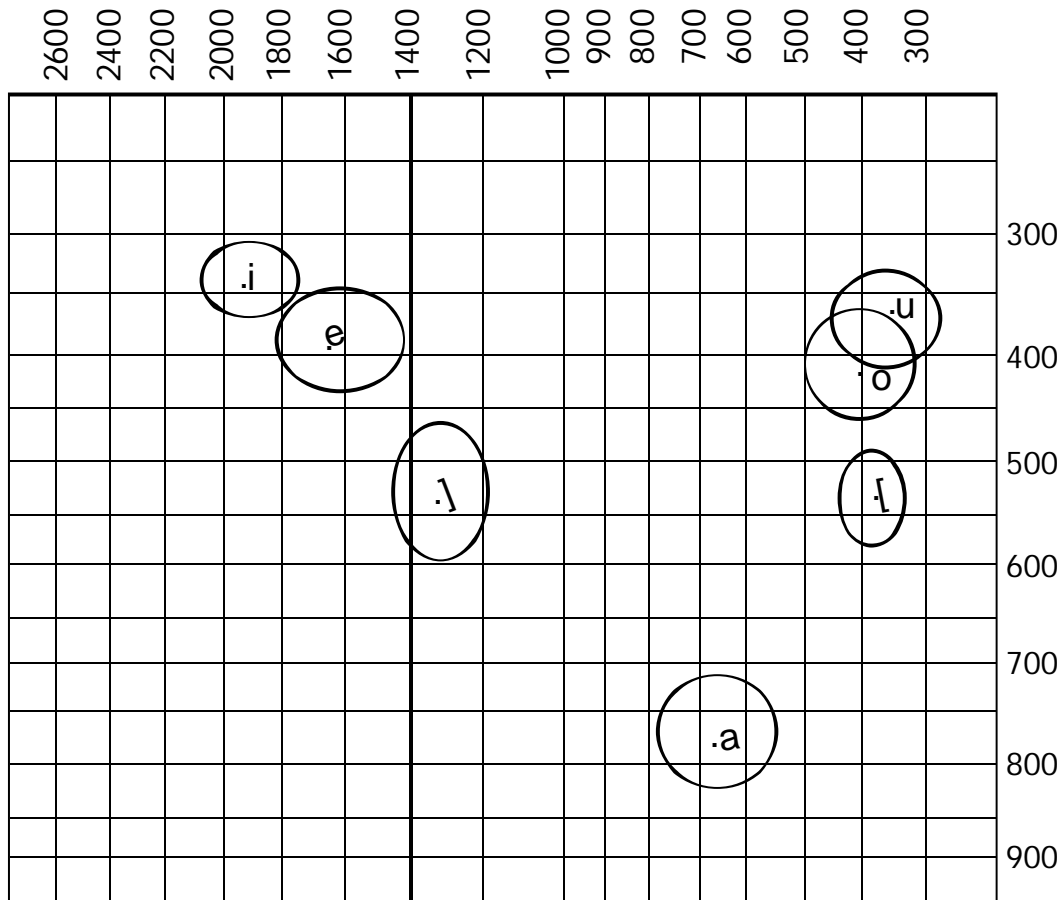


Figure 4.2.1.2 Ellipses of the oral vowels of Abokobi.

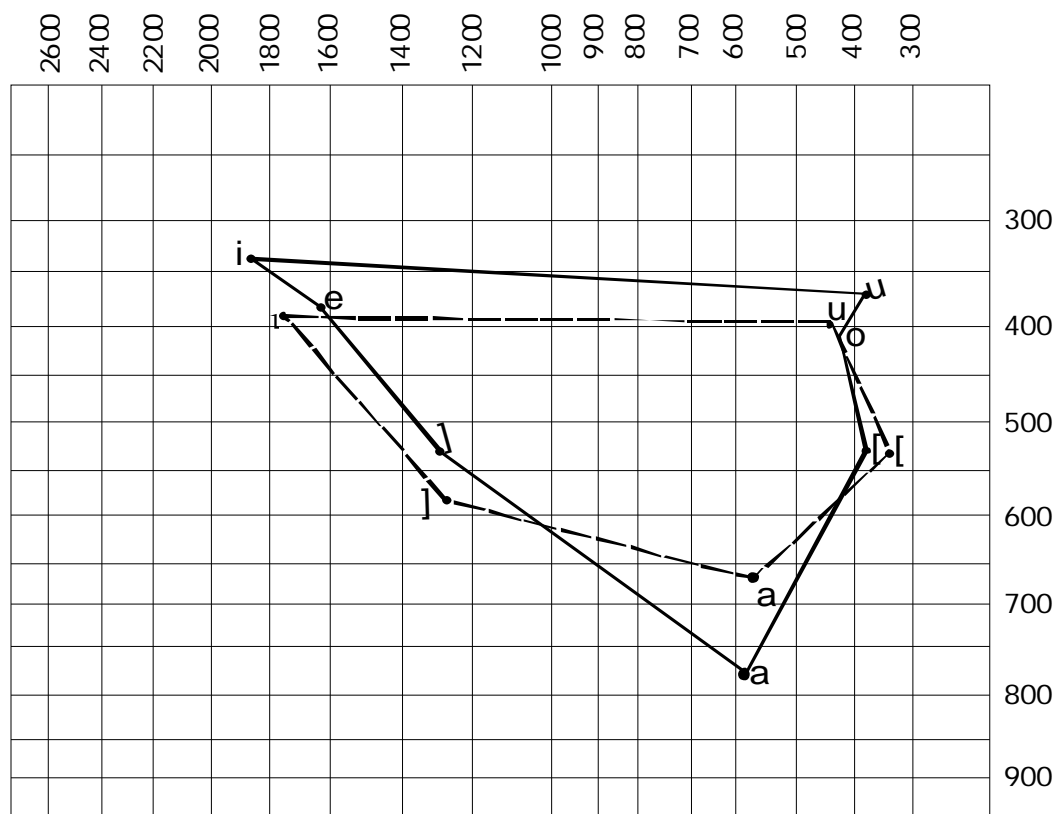
[i] is a high front vowel slightly more front and slightly higher than [e]. It is located at 336Hz on the vertical axis and 1884Hz on the horizontal axis. An ellipsis of [i] drawn with the mean and standard deviation of 27 tokens analyzed lies slightly higher and more front than [e]. [e] is located at 382Hz on the vertical axis and 1619Hz on the horizontal axis. The ellipsis of [e] is slightly lower and less front than [i] but slightly more front and higher than [ɛ]. [ɛ] is located at 536Hz on the vertical axis and 1319Hz on the horizontal axis. The ellipsis of [ɛ] is almost in the middle of the vowel space.

[a] is located at approximately 772Hz on the vertical axis and 661Hz on the horizontal axis. It is located towards the back of the vowel space but is slightly less back than the three back vowels. [ɔ] is located at 529Hz on the vertical axis and 382Hz on the horizontal axis. [ɔ] and [ɛ] are almost of the same height though [ɛ] is in front while [ɔ] is in back space. [o] is located at 405Hz on the vertical axis and 404Hz on the horizontal axis. [o] is slightly more front than [ɔ]. [u] is located at approximately 370Hz on the vertical axis and 367Hz on the horizontal axis. The ellipsis of [u] slightly overlaps with that of [o].

The vowels of Ga as spoken in Abokobi, form a triangular vowel space with the front vowels sloping gently from [i], which is the highest, to [ɛ] which is the lowest in height among the front vowels. The back vowels start from [u] which is the highest back vowel and which slightly overlaps with [o], through [ɔ], and then to [a], which is slightly more front and is the lowest among the back vowels.

A Paired T-test conducted on the overlapping pairs of vowels to determine how significantly different each member of a pair is from the other, shows a high degree of independence between the pairs. The t-test values show significant differences between the overlapping pairs.

A comparison between the oral and nasalized vowels of Abokobi Ga shows a systematic difference in vowel height between cognate pairs. With the exception of the low vowel, [a] (which is lower than its nasalized cognate) all oral vowels are higher on the vowel chart than their nasalized counterparts. Similarly, there seems to be a systematic difference on the front-back dimension between the oral vowels and their nasalized counterparts. With the exception of [u], all oral vowels tend to be less peripheral in terms of the front-back dimension than their nasalized counterparts.



Oral — Nasalized ---
Figure 4.2.1.3 Abokobi oral and nasalized vowel space

4.2.2 Urban Ga (Bukom) Vowels

The corpus for the Bukom vowels was elicited from 10 native speakers (5 men and 5 women) between the ages of 30 and 60. Like the Abokobi Ga speakers, none of these speakers has had any university education. Most of them have had basic education and can read and write. The speakers are mostly traders. The results obtained are presented in Table 4.2.2.1, Figures 4.2.2.1, 4.2.2.2, and 4.2.2.3.

Table 4.2.2.1 F1 and F2' means and standard deviations of Bukom formant frequency values.

Dialect		Vowel	i	e	ɛ	a	ɔ	o	u	ĩ	ẽ	ã	õ	ũ
Bukom	F1	Mean	316	404	586	788	565	400	370	384	628	708	528	439
		Std.dev.	36	40	54	67	48	52	63	77	53	87	77	49
	F2'	Mean	1875	1635	1186	549	354	366	422	1785	1361	551	325	593
		Std.dev.	194	214	118	124	47	39	99	205	148	117	62	166

Table 4.2.2.1 summarizes the means and standard deviations of the F1 and F2' values of each vowel as uttered by the Bukom speakers of Ga. These values are used to plot the vowel ellipses indicated on the Bukom vowel chart (Figure 4.2.2.2) described below.

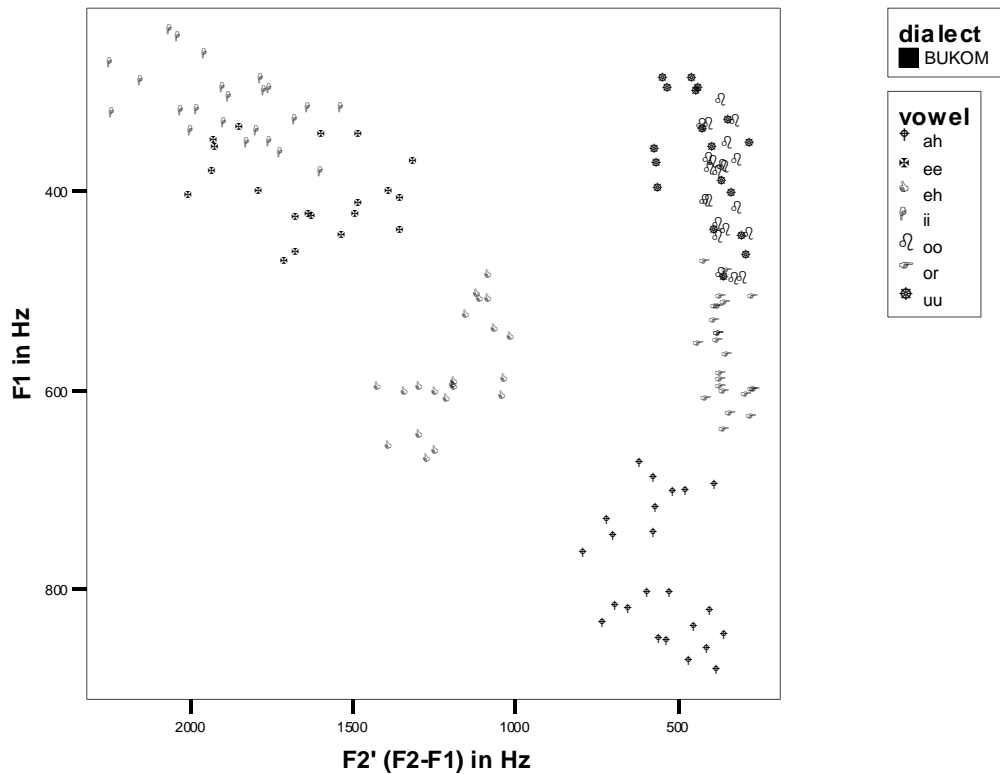


Figure 4.2.2.1 Scatter plot of Bukom oral vowels.

Figure 4.2.2.1 above, is a scatter plot of all tokens of the seven oral vowels of 10 speakers of Bukom Ga. The scatter plot shows a slight overlap between [i] and [e] in the front space and [u] and [o] in the back space. Again there is a slight overlap between [ɔ] and [o] in the back space. A Paired T-test conducted on the overlapping pairs of vowels to determine how significantly different each member of a pair is from the other, shows a high degree of independence within the [i/e] pair but a slight degree of dependence exists between [u] and [o].

The results reveal that the vowels of the Bukom dialect of Ga pattern similarly to Abokobi vowels with only one exception. Like Abokobi, Bukom has three front vowels: [i], [e], [ɛ]; but unlike Abokobi, Bukom has four clear back vowels: [u], [o], [ɔ], [a]. [i], the highest front vowel is located at 316Hz on the vertical axis and 1875Hz on the

horizontal axis. [e] is slightly less front and slightly lower than [i]. It is located at 404Hz on the vertical axis and 1635Hz on the horizontal axis. [ɛ] is located at 586Hz on the vertical axis and 1186Hz on the horizontal axis. [ɛ] is almost in the middle area of the vowel space.

[a] is located close to the back of the vowel space as compared to the central position found in Abokobi. It is located at 788Hz on the vertical axis and 549Hz on the horizontal axis. [ɔ] is located at 565Hz on the vertical axis and 354Hz on the horizontal axis. [o] is at 402Hz on the vertical axis and 357Hz on the horizontal axis. [o] slightly overlaps with [u], which is located at 370Hz on the vertical axis and 422Hz on the horizontal axis. Figure 4.2.2.2 shows a plot of the vowels of Bukom dialect of Ga.

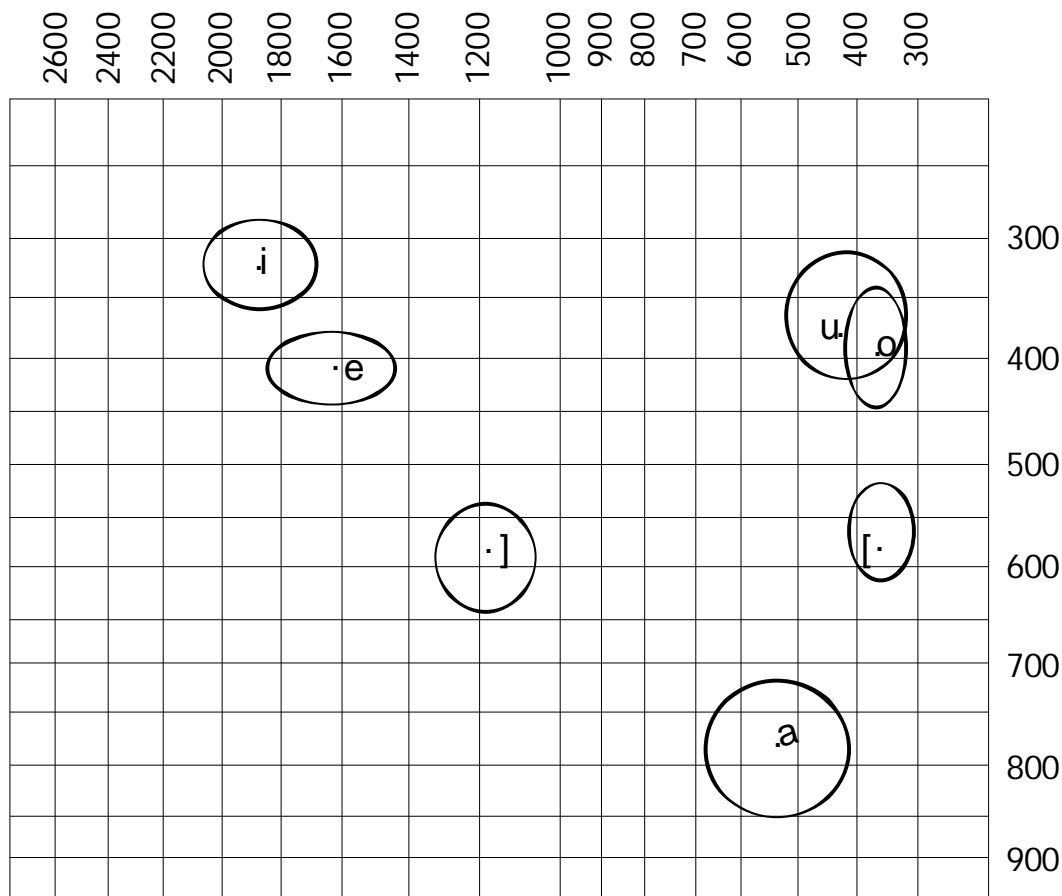


Figure 4.2.2.2 Ellipses of the vowels of Bukom

Moving on to the nasalized vowels, one finds a situation quite similar to that of Abokobi. First one notices that with the exception of the low vowel [ã], all nasalized vowels are

lower in height than their oral cognates. One also notices that [ɤ] is the furthest back of all the back vowels whether oral or nasalized.

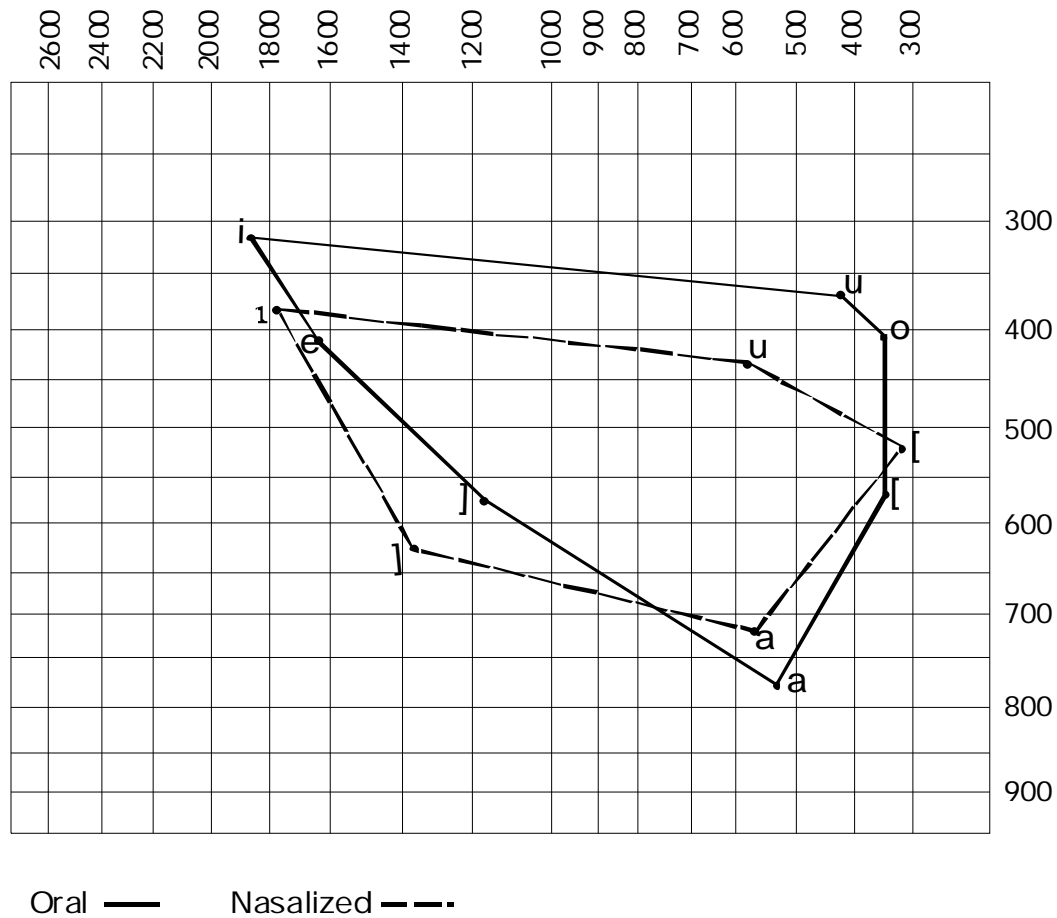


Figure 4.2.2.3 Bukom vowel space

4.2.3 Suburban Ga (Teshie) vowels

The Teshie vowels were elicited from 10 native speakers (five men and five women) between ages 24 and 68 years old, who have lived almost all of their lives in Teshie. All of the speakers have basic education and can read and write. None of them has had any university education and they are basically traders. The results are summarized in Table 4.2.3.1 and Figures 4.2.3.1, 4.2.3.2, and 4.2.3.3.

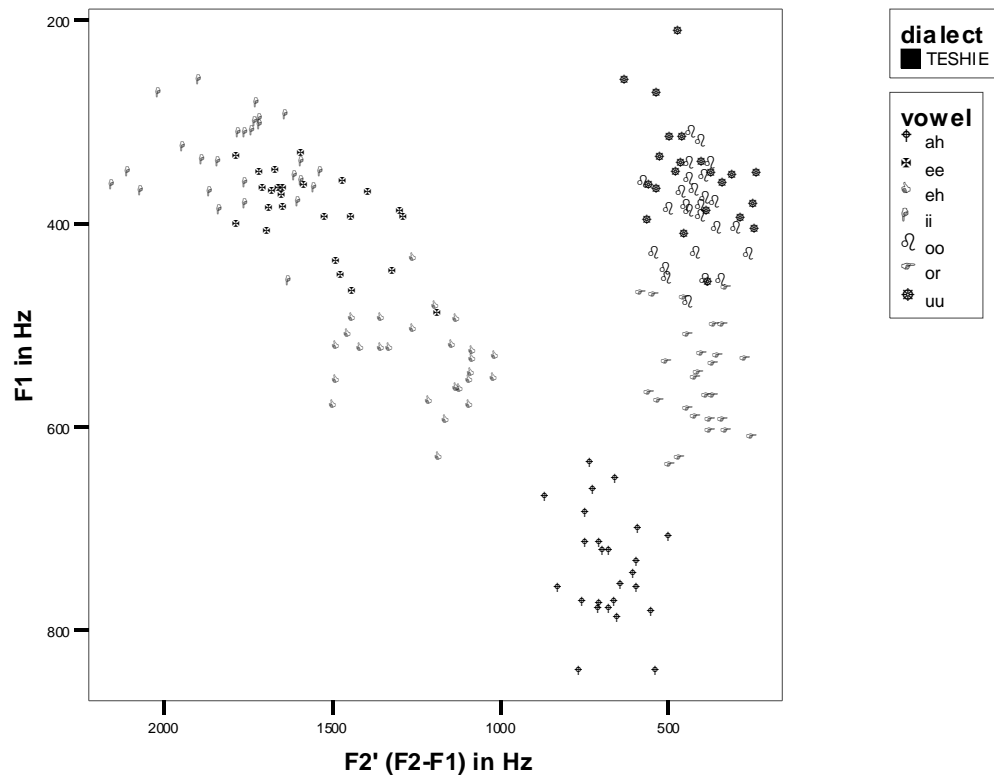


Figure 4.2.3.1 Scatter plot of Teshie oral vowels.

Figure 4.2.3.1 above is a scatter plot of all tokens of the seven oral vowels said by each of the 10 speakers of Teshie Ga. The plot shows a slight overlap between [i] and [e]. In the back of the plot, there is a major overlap between [u] and [o]. A few tokens of [u] and [o] have even strayed to as low as the [ɔ] vowel space. A Paired T-test conducted on the overlapping pairs of vowels to determine how significantly different each member of a pair is from the other, shows a high degree of independence within the [i/e] pair but a slight degree of dependence between [u] and [o]. The T-test values show high significant differences within the [i/e] pair but the [u/o] pair really shows a slight overlap.

Table 4.2.3.1 F1 and F2' means and standard deviations of Teshie formant frequency values.

Dialect		Vowel	i	e	ɛ	a	ɔ	o	u	ĩ	ẽ	ā	ǎ	ũ
Teshie	F1	Mean	341	392	538	742	555	394	352	394	565	686	496	388
		Std.dev.	42	41	40	53	50	44	54	39	81	68	41	107
	F2'	Mean	1773	1550	1230	674	412	422	432	1668	1286	543	354	557
		Std.dev.	170	166	157	88	58	70	112	210	164	73	101	150

Table 4.2.3.1 is a summary of the means and standard deviations of the F1 and F2' values of each vowel as it is uttered by Teshie speakers of Ga. The values are used to plot the points indicated in figure 4.2.3.2.

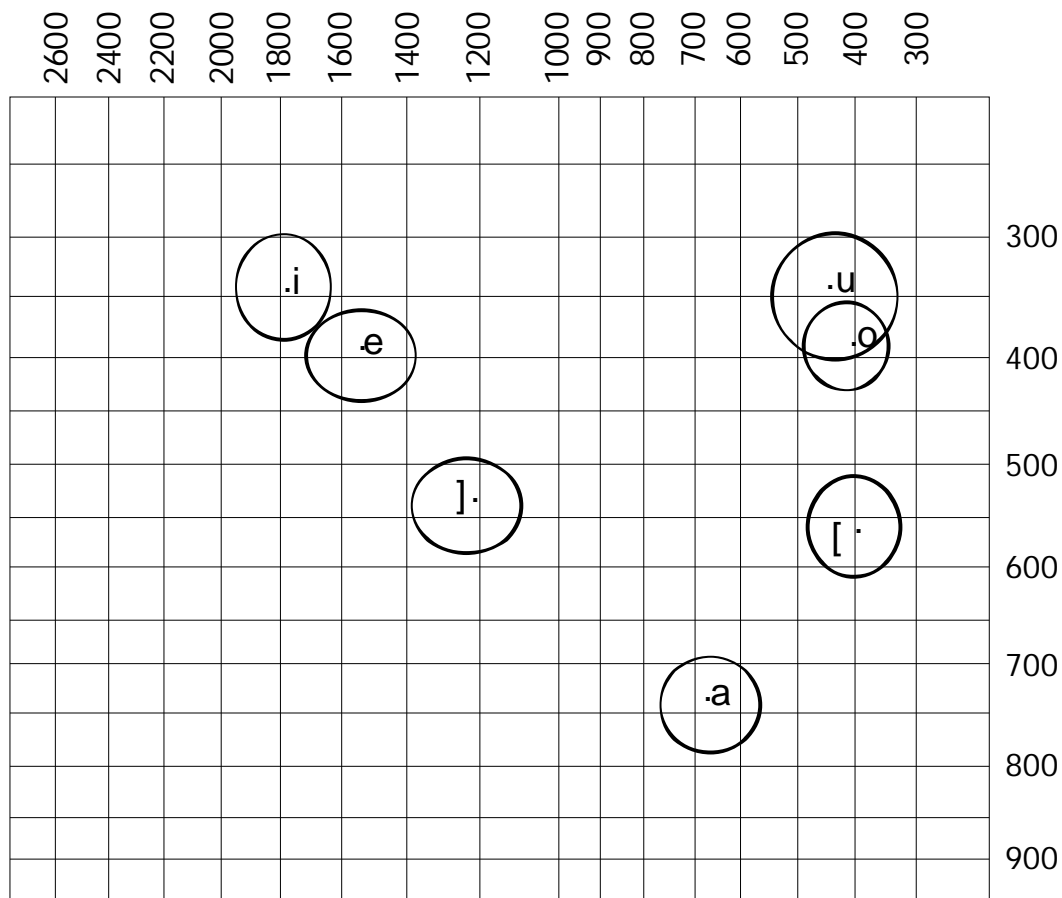


Figure 4.2.3.2 Ellipses of the vowels of Teshie

Teshie oral vowels are made up of three front vowels, one central vowel and three back vowels. The high front vowel [i] is located 341Hz on the vertical axis and 1773Hz on the horizontal axis. It is quite close to [e]. [e] is located at 392Hz on the vertical axis and 1550Hz on the horizontal axis. [ɛ] is located at 538Hz on the vertical axis and 1230Hz on the horizontal axis.

[a] is at 742Hz on the vertical axis and 674Hz on the horizontal axis. [ɔ] is located at 555Hz on the vertical axis and 412Hz on the horizontal axis. [ɔ] occupies the same area on the vertical axis as [ɛ], although [ɛ] is a front while [ɔ] is a back vowel. [o] is located at 394Hz on the vertical axis and 422Hz on the horizontal axis. [u] is located 354Hz on the vertical axis and 425Hz on the horizontal axis. As in the scatter plot, the ellipses show an overlap between [o] and [u].

The situation with the nasalized vowels is not unlike the Abokobi and Bukom ones. The space occupied by the nasalized vowels is almost the same as the other two dialects, with one modification, namely, that /ã/ is also further back than /a/.

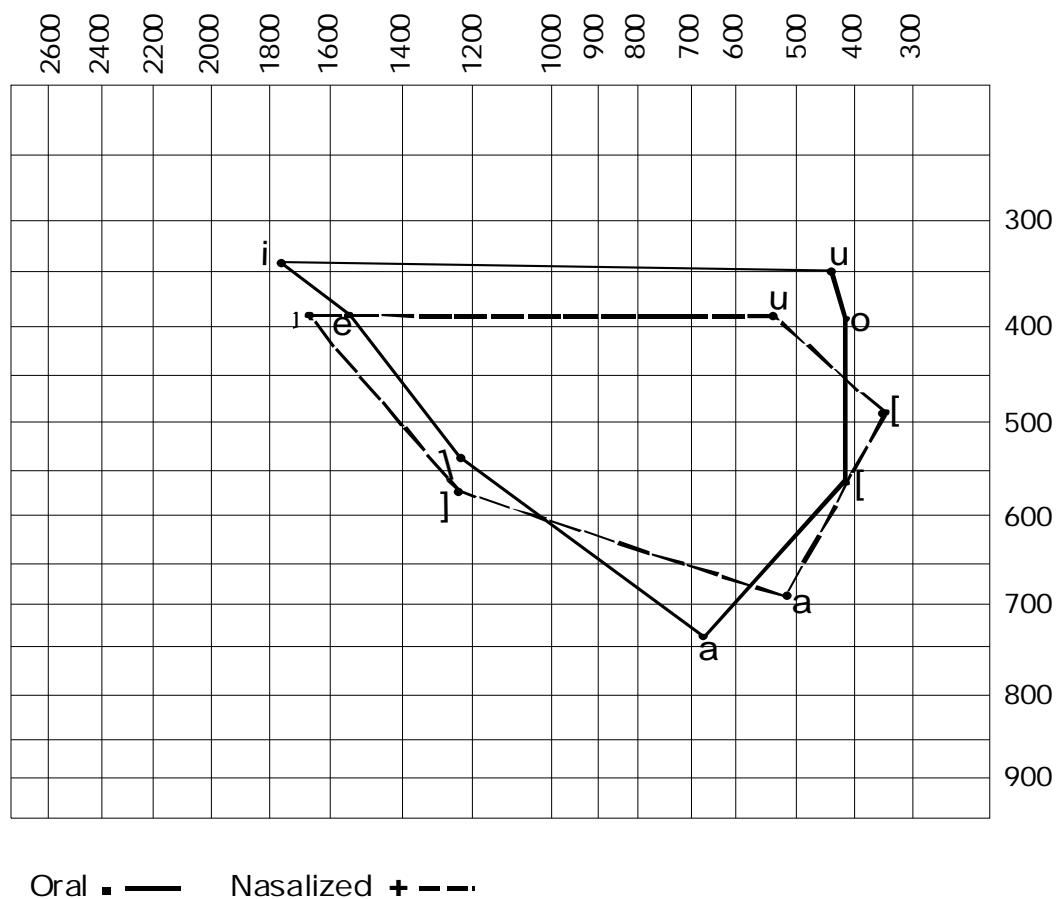


Figure 4.2.3.3 Teshie vowel space

4.2.4. Summary of Ga Vowels

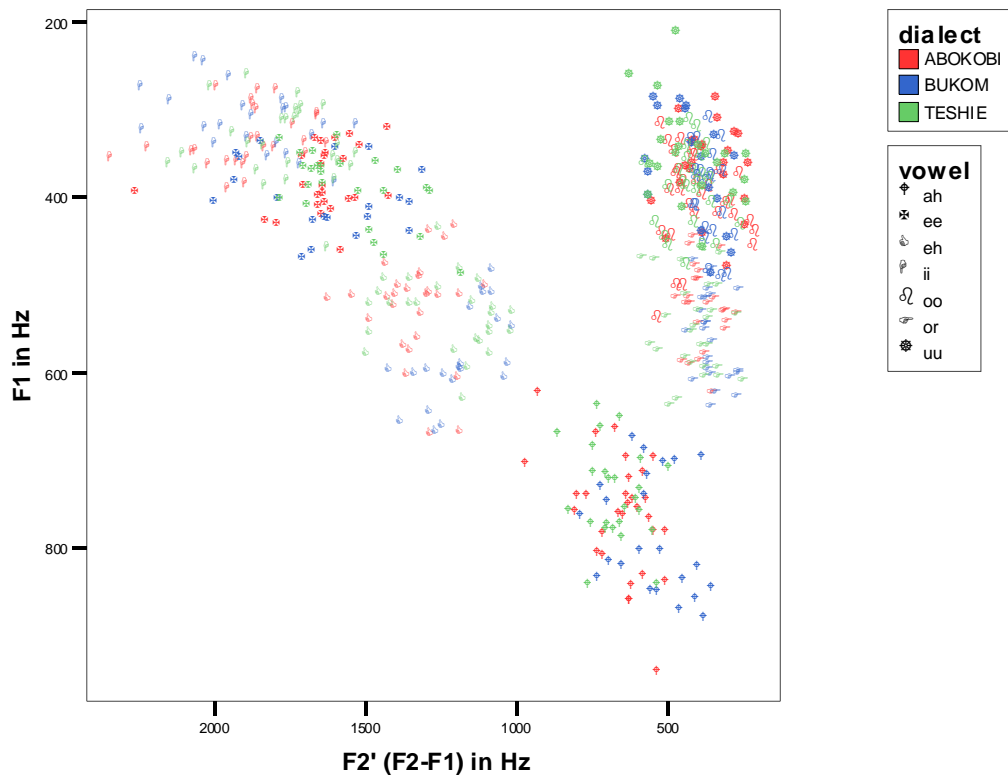


Figure 4.2.4.1 Scatter plot of Ga oral vowels

The scatter plot of Ga vowels show similar patterns for all three dialects of Ga studied. The scatter indicates that of the three dialects of Ga, Bukom's vowels tend to be slightly lower and slightly less front than vowels of the other two dialects. As a result of a few extremely high front productions of /i/, this dialect of Ga seems to spread over a wider space than the other two. But this fact is not borne out after normalization (See Figure 4.2.4.2). In fact, the normalized data indicates that there is no significant difference between the oral vowels of the three dialects. [i] and [e] are very close to each other in space with a very slight overlap in some cases. A very interesting phenomenon is the overlap between /o/ and /u/ in all three dialects. This phenomenon will be discussed further in Chapter 5.

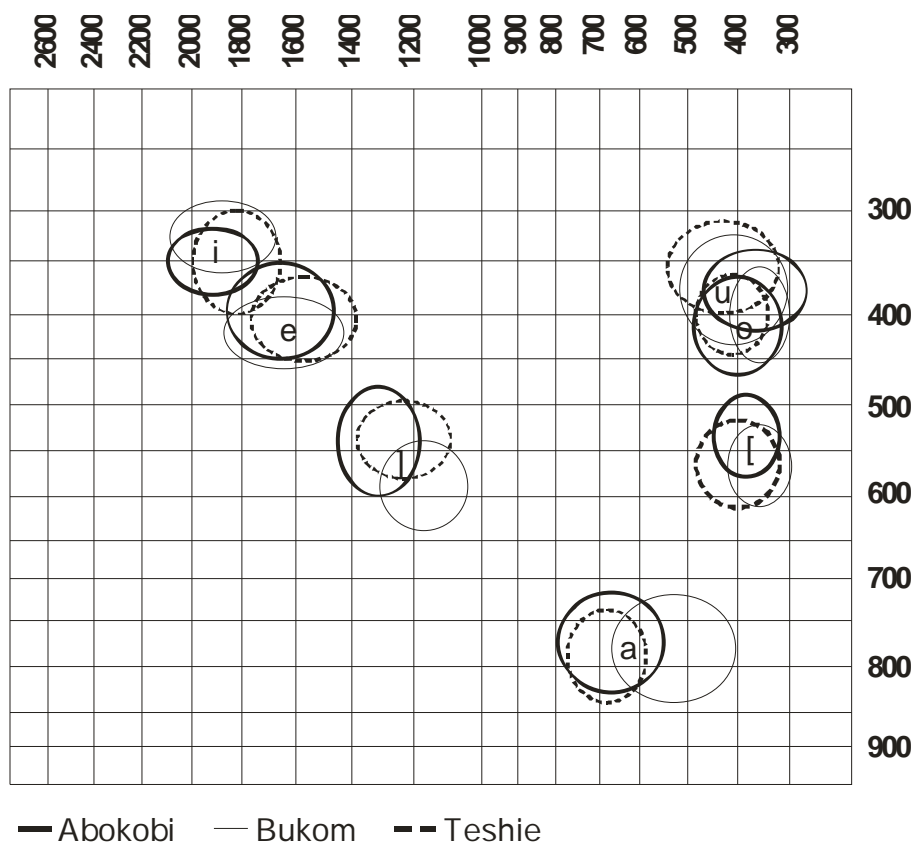


Fig. 4.2.4.2 Ellipses of the oral vowels of Ga

In figures 4.2.4.3 and 4.2.4.4, the normalized vowel data of all 12 Ga vowels, namely, the oral and nasalized vowels are presented. Generally the oral vowels are less spread across vowel spaces than the nasalized ones. [i] and [e] are very close to each other in the front of the vowel space. There is an overlap between [u] and [o] in back of the space. [ɛ] and [ɔ] are about the same height generally. They are located around the same vowel height on the vertical axis, though [ɛ] is a front vowel while [ɔ] is a back one. [a] is located slightly more central than [u] and [o]. It is the lowest vowel (i.e. with the largest value on the vertical axis).

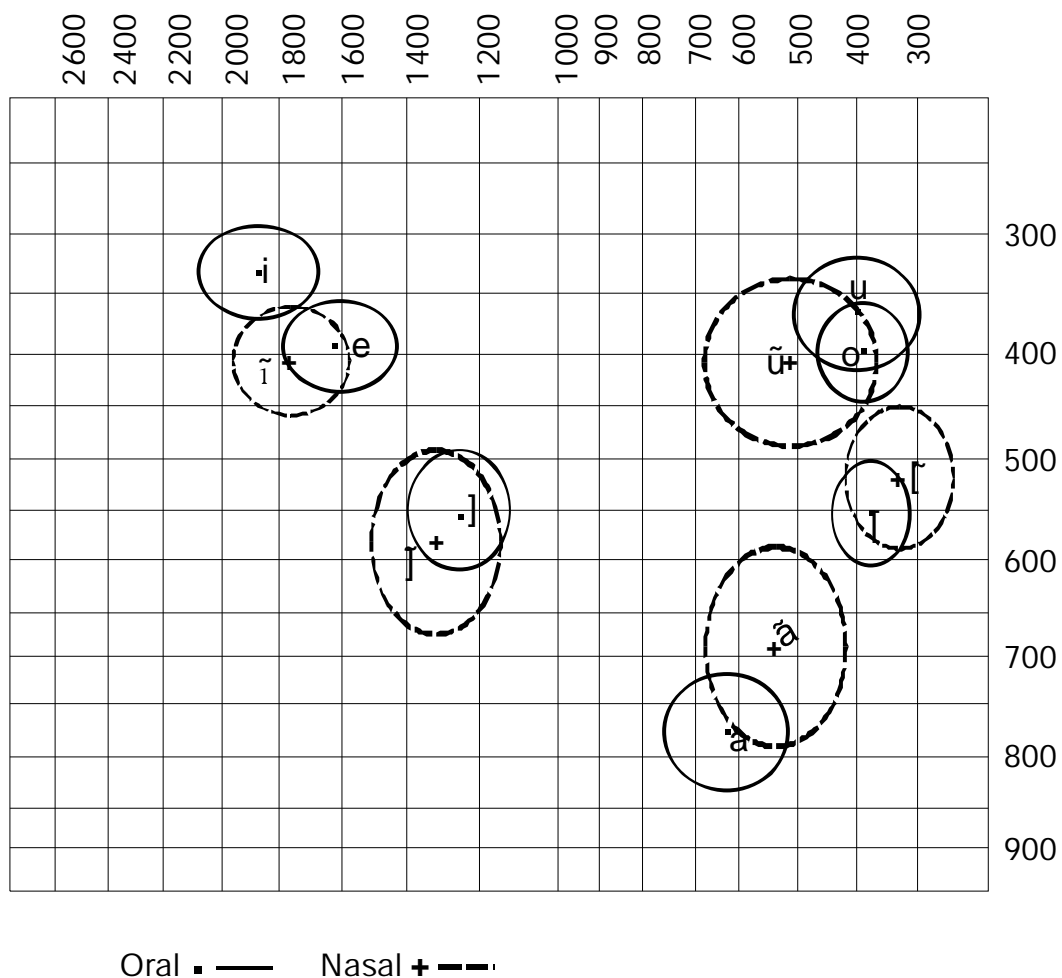


Fig. 4.2.4.3 Ellipses of the oral and nasalized vowels of Ga

The nasalized vowels of the Ga language are arranged in the vowel space in such a way that they minimize the vowel space. On the dimension of height, the low vowel in the nasalized space is higher than the low vowel in the oral vowel space, and the high vowels in the nasalized space are lower than the high vowels in the oral space. On the front/back dimension, the nasalized vowel space is skewed towards the front except for [ɔ̃] which is the most back vowel and [ã] which is slightly less front than its oral counterpart. In all, the nasalized vowels space is much more compact along the height dimension than the oral one. Along the front-back dimension, however, the nasalized vowel space seems slightly wider than the oral one.

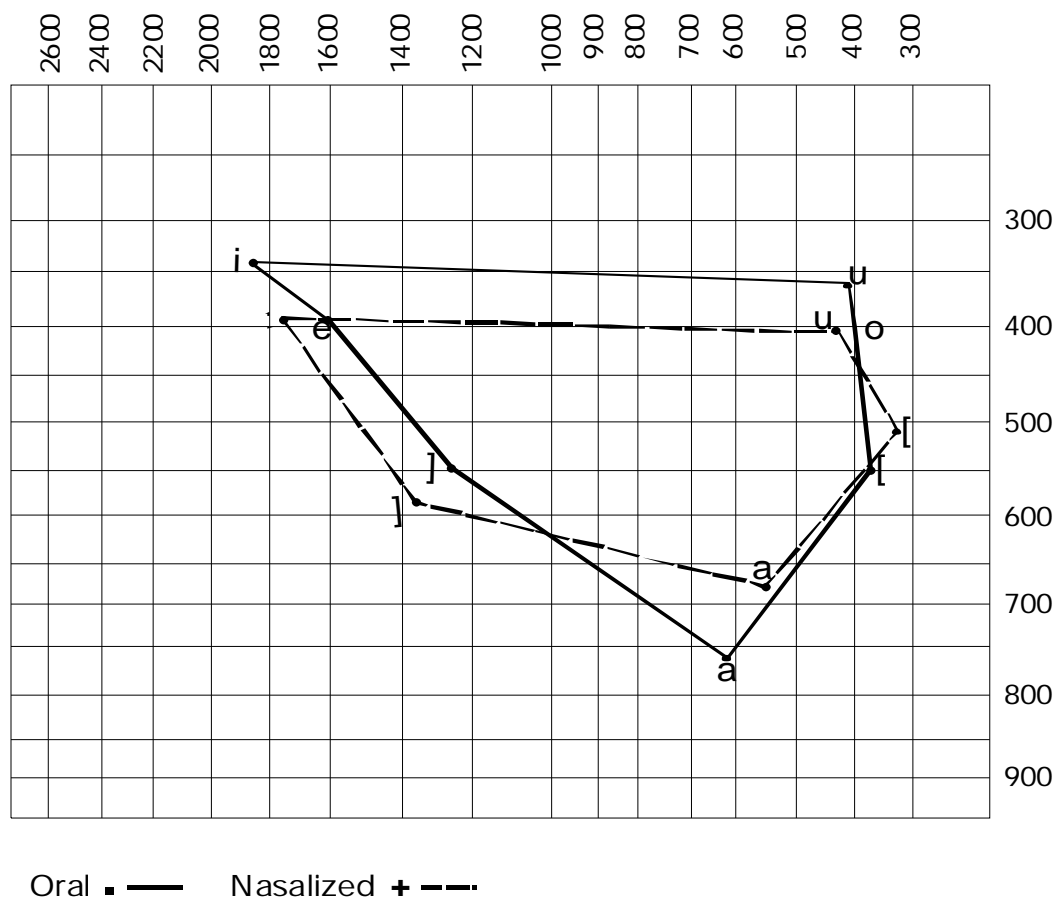


Fig. 4.2.4.4 The Ga vowel space

Table 4.2.4.1 presents the results of a one-way analysis of variance for all vowels of the three dialects of Ga. It is clear from the table that there are no significant differences between the individual vowel sounds of the three dialect areas. It must be noted here that /u/ seems to display a slight degree of interdependence, but as can be seen, the difference at $p < 0.074$ is not significant at the 95% level of confidence. Further tests were carried out on the seemingly overlapping pairs of vowels across the dialects. The results, presented in Table 4.2.4.2, indicate that with the exception of the [i]/[ĩ] opposition, all the vowels are significantly different from each other. Interestingly, the seeming overlap between [o] and [u] shows a significant difference (at $p < 0.014$) while the slight overlap between [i] and [ĩ] show a strong interdependency (at $p < 0.350$).

Table 4.2.4.1 Results for Analysis Of Variance across dialects of Ga language

Paired vowels	F-value	Df	Sig. (2-tailed)
i	0.125	2	0.882
e	0.143	2	0.867
ɛ	0.398	2	0.672
a	0.674	2	0.511
ɔ	0.515	2	0.598
o	0.493	2	0.611
u	0.613	2	0.543
ĩ	0.104	2	0.901
ẽ	0.433	2	0.649
ã	0.062	2	0.940
õ	0.019	2	0.981
ũ	2.653	2	0.074

Table 4.2.4.2 Results of Paired Samples Test for Ga

Paired vowels	T-value	Df	Sig. (2-tailed)
i/e	8.359	209	0.000
u/o	2.494	182	0.014
i/ĩ	0.937	197	0.350
ɛ/ẽ	-4.333	200	0.000
a/ã	9.911	182	0.000
ɔ/õ	8.212	179	0.000
u/ũ	-7.945	131	0.000

In order to test for the significant differences between vowel sounds with slight overlaps, a paired sample test was conducted on the suspect vowels. The pairs of vowels tested are: [i/e], [u/o], [i/ĩ], [ɛ/ẽ], [a/ã], [ɔ/õ], [u/ũ]. The results show that at a confidence level of 95%, all the pairs tested are significantly different except the [i/ĩ], pair for Ga which has a significant value of 0.350.

4.3 VOWELS OF THE DANGME LANGUAGE AREA

The vowels of the Dangme language are presented below. Ada vowels are presented first, followed by Shai vowels and then the vowels for Krobo. In each of the Dangme dialects, 12 vowels were repeated 3 times each by 10 speakers in the same phonetic environments between two bilabial plosives [b] and [p] (in the frame “mo de ___ pɛ”). In each case, test words that are not pronounced as they are normally pronounced by the native speakers were rejected. Similarly, test words that are pronounced with different tones other than the high tone were left out. The vowels analyzed are made up of seven oral vowels and five nasalized vowels.

As in the case of the Ga language, results are presented in both figures and tables. The tables show mean F1 and F2' values as well as standard deviations and levels of significant differences, if any. The figures include scatter plots of all vowels as well as mean values together with ellipses drawn on a vowel chart. All ellipses were drawn using two standard deviations of the F1 and F2'. The mean of the F1 and F2' values were used to plot the vowel space of each dialect.

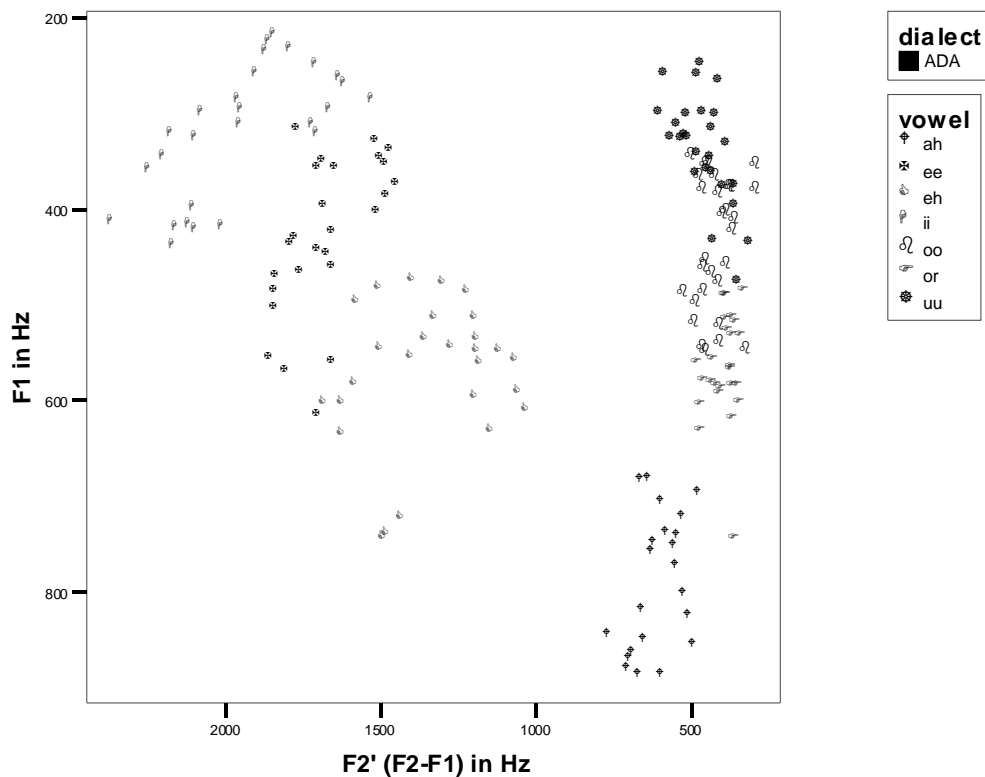


Fig. 4.3.1.1 Scatter plot of Ada oral vowels

4.3.1 Ada (Big Ada) Vowels

The Ada vowels were elicited from 10 native speakers (5 men and 5 women) between ages 25 and 57 years old, who have lived almost all of their lives in Ada. All of the speakers have basic education and can read and write. None of the speakers has had up to university education and they are basically traders and apprentices.

The results obtained are presented in Table 4.3.1.1 and Figures 4.3.1.1, 4.3.1.2 and 4.3.1.3. The table summarizes the mean and standard deviations of the F1 and F2' values of each vowel (the actual F1 and F2' values of the vowels are presented in appendix). The figures show the scatter plot and the ellipses of oral vowels and the vowel spaces of the oral and the nasalized vowels. The mean of the F1 and F2' values were used to plot the vowel space of the dialect.

The scatter plot of the vowels of Ada as shown in figure 4.3.1.1 indicates the pattern of the Ada oral vowels. It shows that [i] is located slightly higher and more front than [e], with a few tokens of [i] slightly overlapping with [e] tokens. There is a slight overlap between [e] and [ɛ]. [a] is almost as back as the rest of the back vowels and it occupies the lowest space within the chart. There is a slight overlap between [ɔ] and [o] and also between [o] and [u]. A paired sample T-test conducted to determine the levels of significant differences within the overlapping pairs showed that at a confidence level of 95%, each member of the pairs is significantly different from the other.

Table 4.3.1.1 F1 and F2' means and standard deviations of Ada formant frequency values.

Dialect		Vowel	i	e	ɛ	a	ɔ	o	u	ĩ	ẽ	ã	õ	ũ
Ada	F1	Mean	321	321	573	792	568	438	338	356	578	696	584	411
		Std.dev.	68	81	74	70	55	68	56	54	117	65	110	85
	F2'	Mean	1944	1672	1340	608	396	424	464	1938	1397	579	357	467
		Std.dev.	220	130	194	77	43	58	75	239	226	120	95	177

Ada oral vowels as indicated in the vowel space (see Figure 4.3.1.2) include three front vowels and four back vowels. The high front vowel [i] is located at 321Hz on the vertical axis and 1944Hz on the horizontal axis. It lies slightly higher and more front than [e]. [e] is located at 431Hz on the vertical axis and 1672Hz on the horizontal axis. [e] is closer to [i] than it is to [ɛ]. [ɛ] is at 573Hz on the vertical axis and 1340Hz on the horizontal axis.

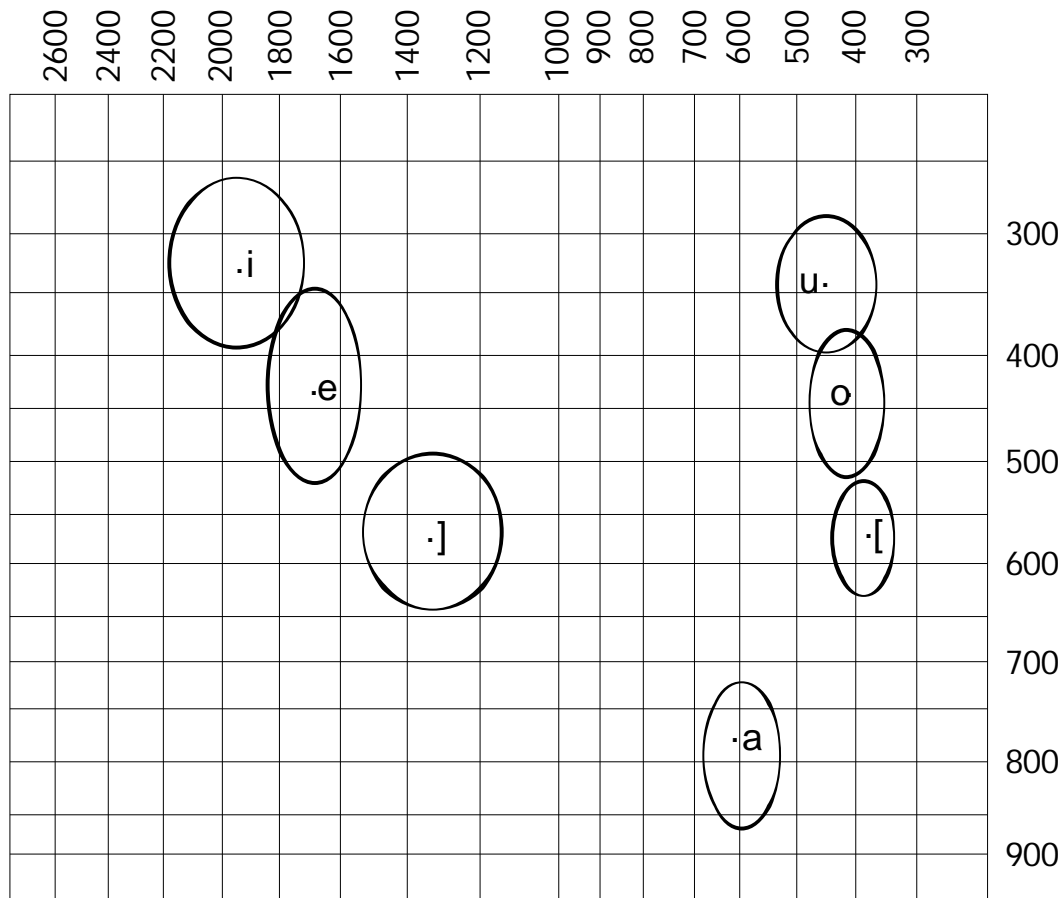


Fig. 4.3.1.2 Ellipses of the oral vowels of Ada

[a] is located at 792Hz on the vertical axis and 608Hz on the horizontal axis. [a] occupies a position almost to the back of the vowel space, though not as far back as the other three. [ɔ] is located at 568Hz on the vertical axis and 396Hz on the horizontal axis. [ɔ] occupies a slightly more back position than the other back vowels. [o] is located at 438Hz on the vertical axis and 424Hz on the horizontal axis. It lies slightly higher in the vowel space than [ɔ] and slightly overlaps with [u]. [u] is located at 338Hz on the vertical axis and 464Hz on the horizontal axis. [u] slightly overlaps with [o]. Figures 4.3.1.2 and 4.3.1.3 present the ellipses, and the mean plots of the vowel space.

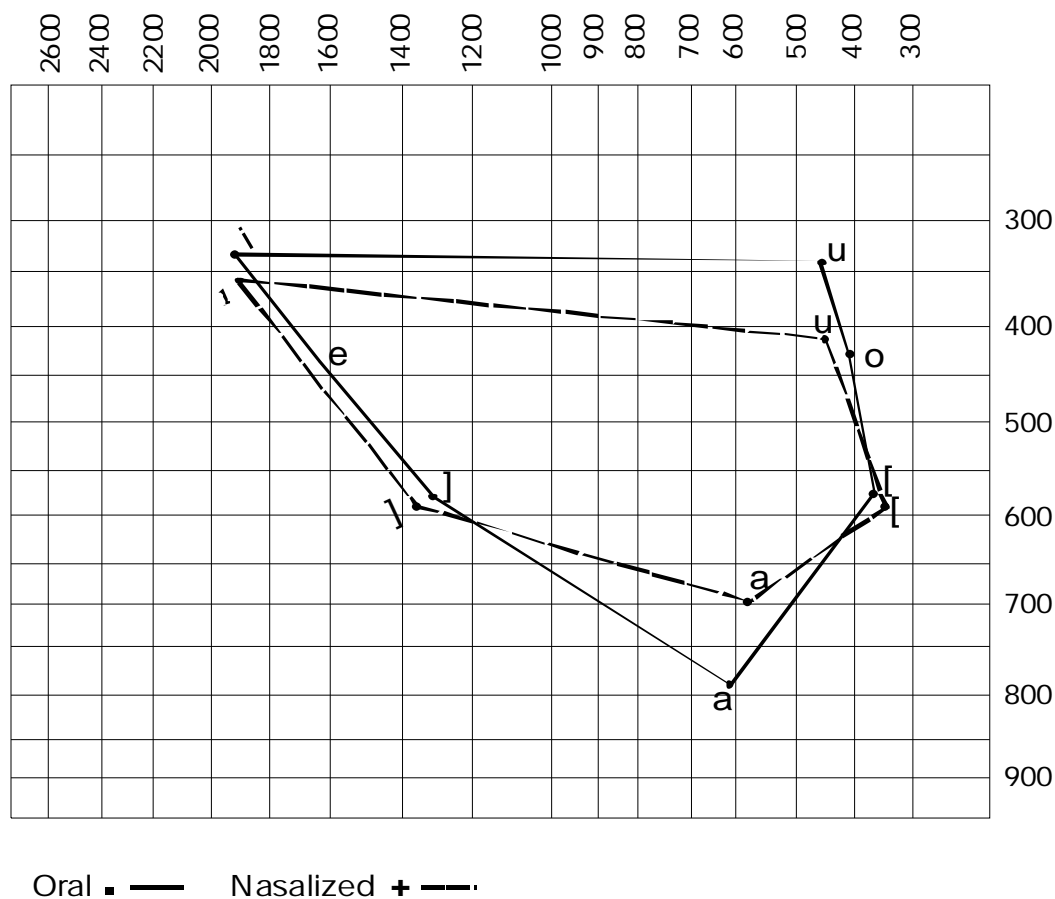


Fig. 4.3.1.3 Ada vowel space.

Figure 4.3.1.3 presents all seven oral and five nasalized vowels. Two things stand out immediately. First, it is evident that while oral [i] and [u] are about the same height on the vowel chart, nasalized [ĩ] is much higher than nasalized [ũ]. Second, it is equally evident that the nasalized vowel space is a narrower version (in terms of height) of the oral one. As in the case of all three Ga dialects, nasalized [ɔ̃] is the backmost vowel on the chart. Similarly, as with the Ga dialects, nasalized [ã] is much higher than oral [a].

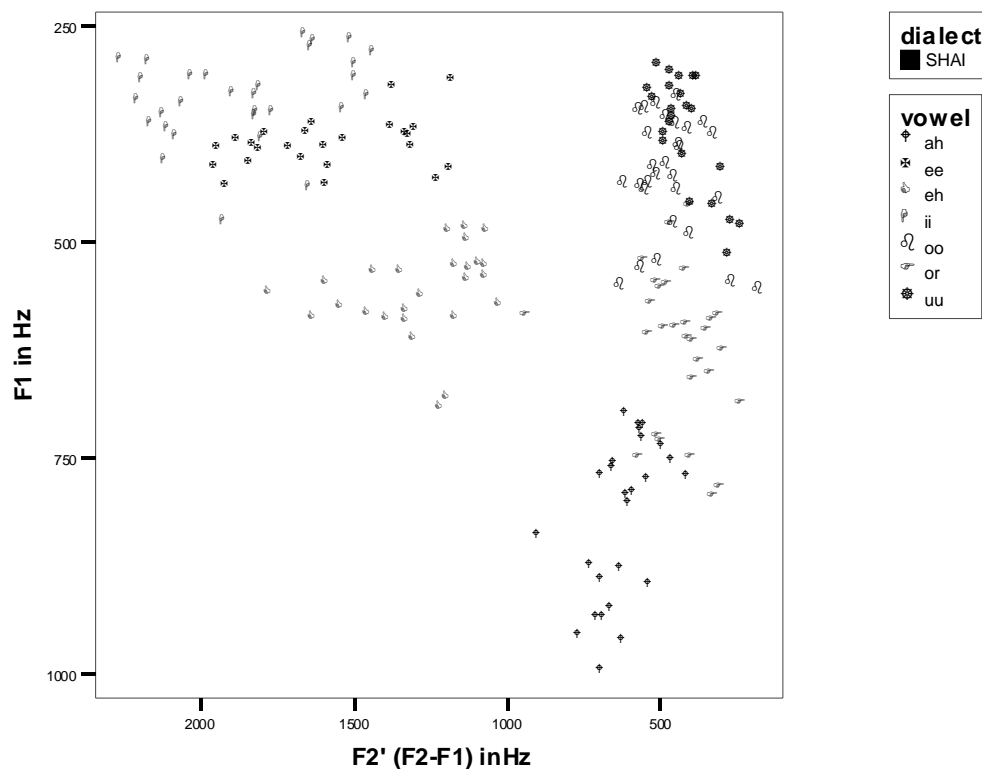
4.3.2 Shai (Doryumu) Vowels

The Shai vowels were elicited from 10 native speakers (5 men and 5 women) between ages 35 and 50 years old, who have lived almost all of their lives in Doryumu. All of the speakers have basic education and can read and write. None of the speakers has had up to university education and they are basically traders.

The results obtained are present in Table 4.3.2.1 and Figures 4.3.2.1, 4.3.2.2 and 4.3.2.3. The table summarizes the mean and standard deviations of the F1 and F2' values of each vowel.

Table 4.3.2.1 F1 and F2' means and standard deviations of Shai formant frequency values.

Dialect		Vowel	i	e	ɛ	a	ɔ	o	u	ĩ	ẽ	ã	õ	ũ
Shai	F1	Mean	336	389	561	823	568	426	374	410	594	730	607	389
		Std.dev.	49	29	51	91	55	67	64	67	121	121	101	61
	F2'	Mean	1853	1582	1255	623	396	470	418	1795	1346	580	395	491
		Std.dev.	260	253	243	101	43	104	84	362	187	118	110	188



4.3.2.1 Scatter plot of Shai oral vowels

Like the Ada dialect, the Shai vowel space includes three front vowels: [i], [e], [ɛ]; and four back vowels; [u], [o], [ɔ], [a]. The [i] sound of Shai Dangme is located at 336Hz on the vertical axis and 1853Hz on the horizontal axis. An ellipsis of [i] drawn around the mean of 30 tokens lies slightly higher and more front than [e] while slightly overlapping with [e] towards the lower end. [e] is located at 389Hz on the vertical axis and 1582Hz on the horizontal axis. [e] is slightly more front and is higher than [ɛ]. [ɛ] is located at 561Hz on the vertical axis and 1255Hz on the horizontal axis. The ellipsis of [ɛ] is almost in the middle of the vowel space.

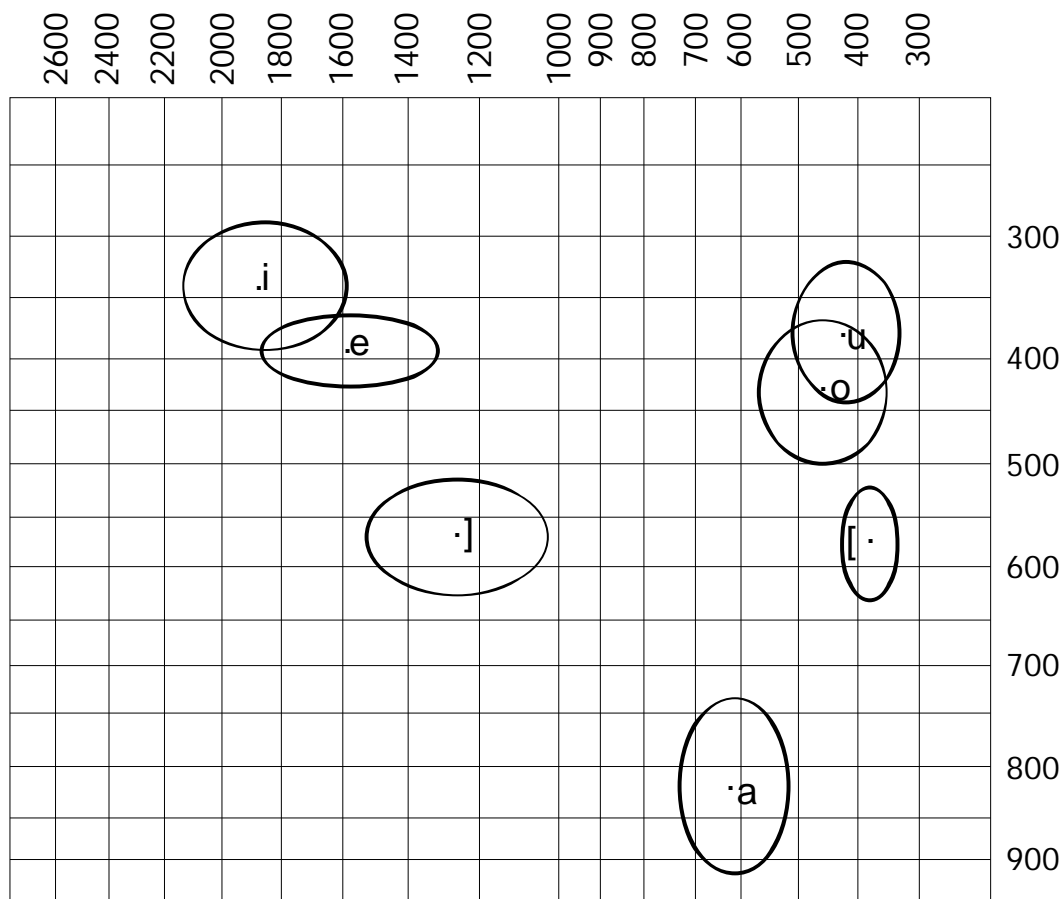


Figure 4.3.2.2 Ellipses of the vowels of Shai

[a] is located at 823Hz on the vertical axis and 623Hz on the horizontal axis. It is located almost in the back of the vowel space but is slightly less back than the other back vowels. [ɔ] is located at 568Hz on the vertical axis and 396Hz on the horizontal axis. [o] is at 426Hz on the vertical axis and 470Hz on the horizontal axis. [o] is slightly more central

than [ɔ] and it slightly overlaps with [u]. [u] is located at 374Hz on the vertical axis and 418Hz on the horizontal axis. [u] is slightly more back than [o].

The vowel space of Shai dialect of Dangme is quite similar to that of Ada except that Shai [i] slightly overlaps with [e]; also Shai [a] is lower than that of Ada. The size and shape of the vowel space of Shai is more similar to that of Ada than it is to that of Krobo (see Section 4.3.3). Figures 4.3.2.2 and 4.3.2.3 show plots of the vowel space of Shai dialect of Dangme plotted as ellipses of the oral vowels, and the oral and nasalized vowel space.

Figure 4.3.2.3 presents all 12 vowels (seven oral and five nasalized) of the Shai dialect of Dangme. The story is almost the same as all three Ga dialects and Ada Dangme, with one notable exception. Nasalized [ɛ̃] in Shai Dangme is not the backmost vowel on the chart. On the contrary, it is more central than any of the back vowels – with the exception of [a]. Generally, all other relationships between the oral and nasalized vowel cognates are the same as for all the other GaDangme dialects.

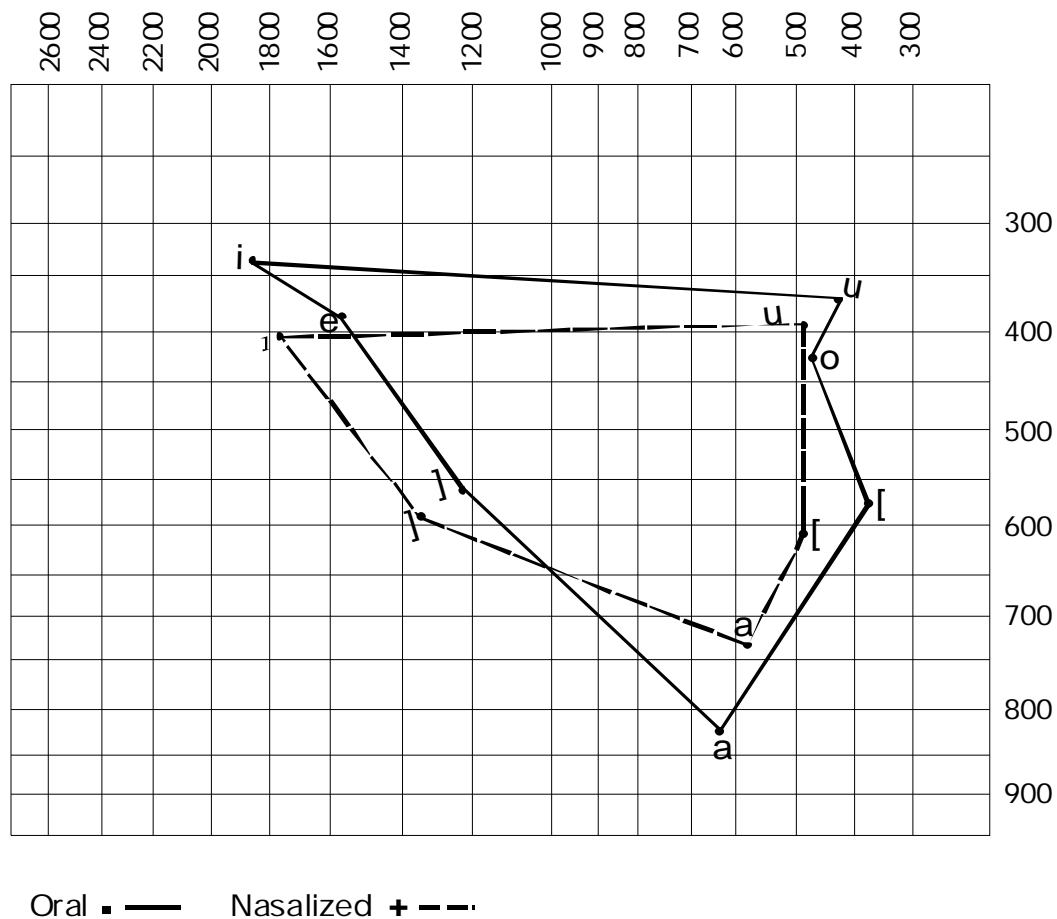


Figure 4.3.2.3 Shai vowel space.

4.3.3 Krobo (Odumase) Vowels

The Krobo vowels were elicited from 10 native speakers (5 men and 5 women) between ages 38 and 60 years old, who have lived almost all of their lives in Odumase. All of the speakers have basic education and can read and write. None of the speakers has had up to university education and they are basically traders.

The results obtained are present in table 4.3.3.1 and figures 4.3.3.1, 4.3.3.2 and 4.3.3.3. The tables summarize the mean and standard deviations of the F1 and F2' values of each vowel.

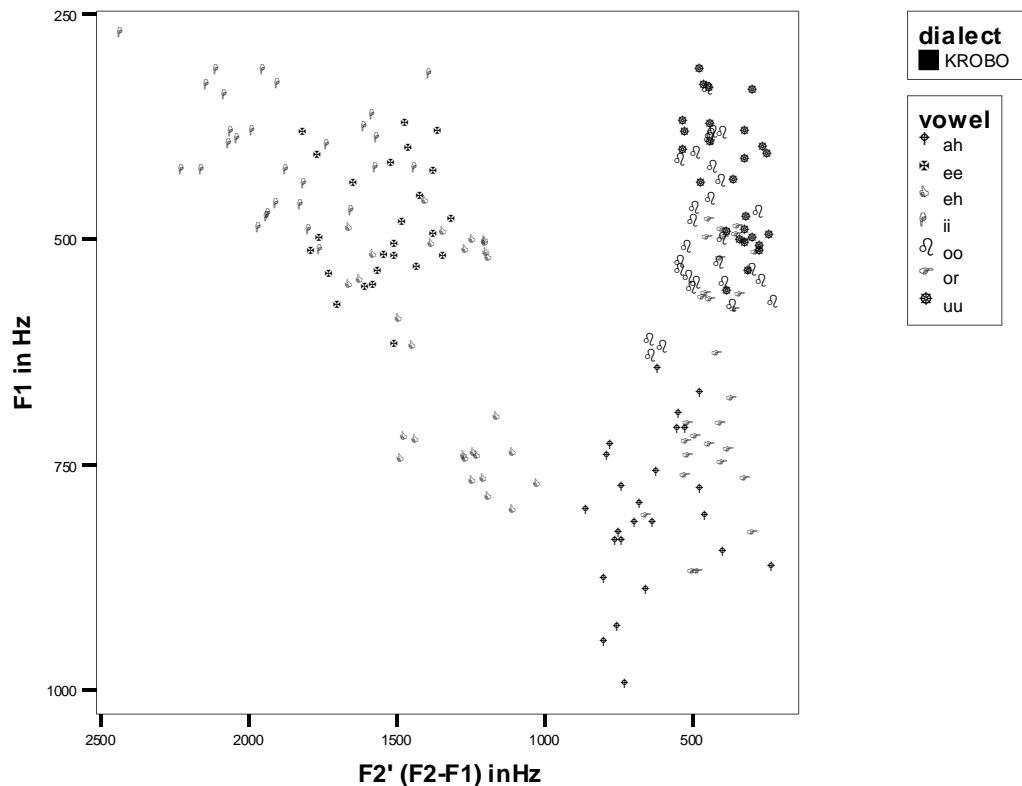


Figure 4.3.3.1 Scatter plot of Krobo oral vowels

The scatter plot of Krobo oral vowels show that Krobo vowels are more widely spread than the rest of Dangme. There are three front vowels and four back vowels. The [i] scatter is slightly higher and more front than that of [e] with some few tokens of [i] overlapping with that of [e]. [e] lies slightly lower and slightly less front than [i]. Again, some tokens of [e] slightly overlap with [ɛ] tokens. [a] the lowest vowel in the plot seems

more like a central vowel and it slightly overlaps with [ɔ] which is slightly more back and slightly higher. The [u] scatter is the highest back vowel. It is slightly higher than and almost as back as [o]. Some tokens of [u] and [o] overlap. A paired samples test on the seemingly overlapping pairs showed that with the exception of the [i/ĩ] pair, all the members of each pair are significantly different.

Table 4.3.3.1 F1 and F2' means and standard deviations of Krobo formant frequency values.

Dialect		Vowel	i	e	ɛ	a	ɔ	o	u	ĩ	ẽ	ã	õ	ũ
Krobo	F1	Mean	405	487	635	808	648	495	436	448	634	733	640	471
		Std.dev.	63	66	120	86	127	80	71	68	96	92	86	60
	F2'	Mean	1876	1540	1319	638	421	451	367	1864	1442	601	326	553
		Std.dev.	245	149	174	152	82	103	92	261	140	138	74	161

The vowels of Krobo dialect of Dangme pattern similarly to that of Ada dialect except that there are larger standard deviations and therefore larger ellipses for the Krobo vowels. Krobo vowel space is such that there are three front vowels: [i], [e], [ɛ]; and four back vowels; [u], [o], [ɔ], [a]. (See Figure 4.3.3.2.)

The [i] sound of Krobo dialect of Dangme is located at 405Hz on the vertical axis and 1876Hz on the horizontal axis. The ellipsis of [i] drawn with the mean and standard deviation of 29 tokens analyzed lies slightly higher and more front than [e]. [e] is located at 487Hz on the vertical axis and 1540Hz on the horizontal axis. The ellipsis of [e] lies slightly lower and less front than [i]. [ɛ] is located at 635Hz on the vertical axis and 1319Hz on the horizontal axis. The ellipsis of [ɛ] is slightly less front than that of [e] but with a larger standard deviation.

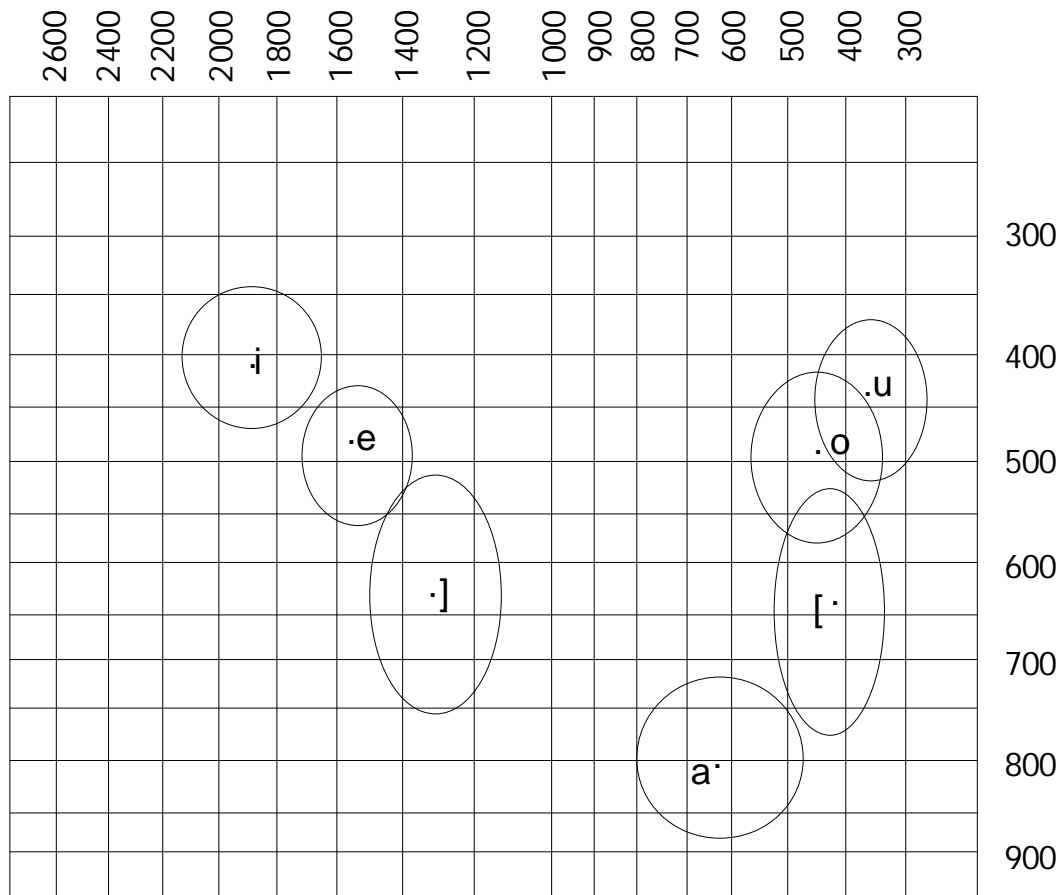


Figure 4.3.3.2 Ellipses of the vowels of Krobo

[a] is located at 808Hz on the vertical axis and 638Hz on the horizontal axis. It is located in the back of the vowel space but is slightly less back than the other back vowels. [ɔ] is located at 648Hz on the vertical axis and 421Hz on the horizontal axis. [ɔ] and [ɛ] occupy almost the same height on the vertical axis though [ɛ] is in front while [ɔ] is in back. The ellipsis of [ɔ] slightly overlaps with that of [o]. [o] is at 495Hz on the vertical axis and 451Hz on the horizontal axis. [o] is slightly more front than [ɔ] and it overlaps slightly with [u]. [u] is located at 436Hz on the vertical axis and 367Hz on the horizontal axis and slightly overlaps with [o], which is slightly more back than the latter.

The vowels of Dangme as spoken by the Krobo people form a vowel space which is wider and lower than that of the Ada and Shai people. Fig 4.3.3.3 presents the plot of oral and nasalized vowels.

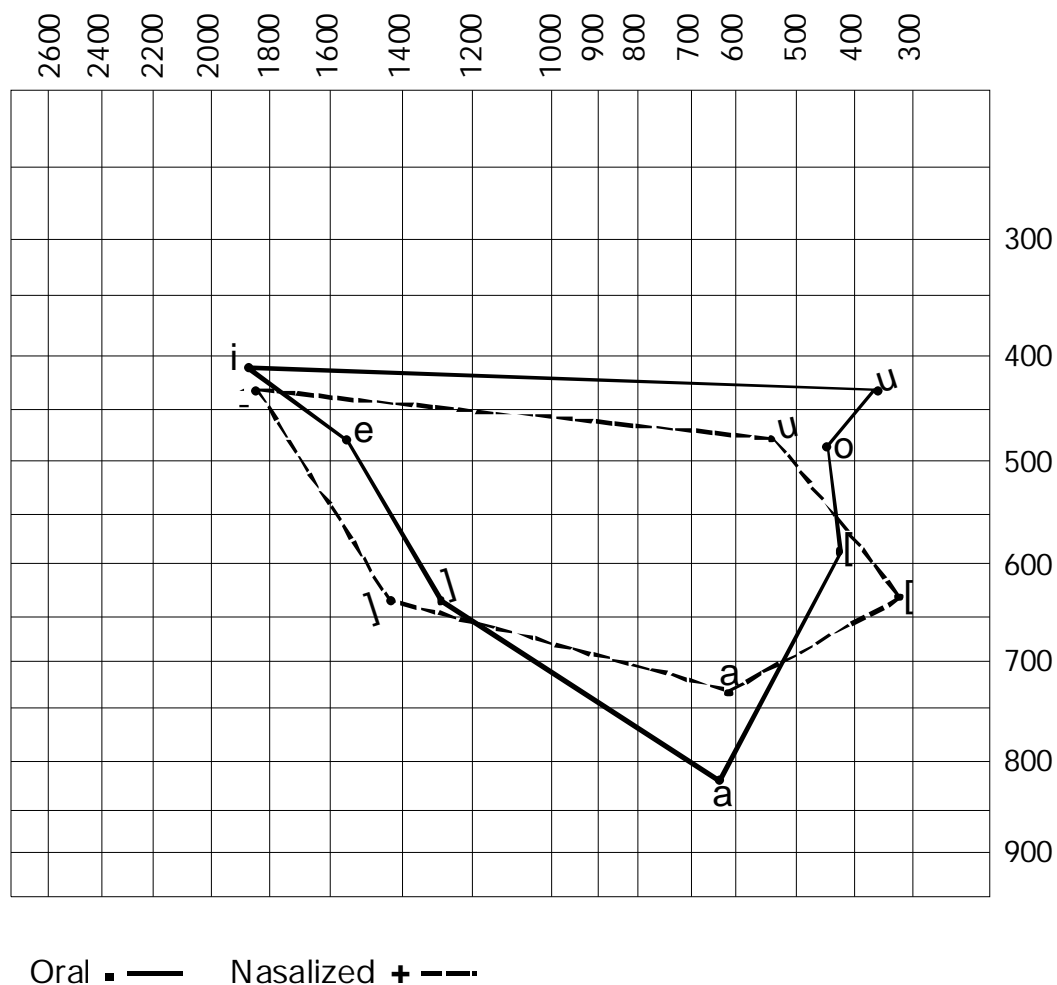


Figure 4.3.3.3 Krobo vowel space

Figure 4.3.3.3 presents all 12 vowels (seven oral and five nasalized) of Krobo Dangme. It is evident from the figure that nasalization in Krobo Dangme has similar effects on vowels as it does in all Ga and Ada Dangme. As in these dialects of GaDangme, nasalized [ɔ̃] is the backmost vowel on the vowel chart. The main difference between the Krobo dialect and the rest of the GaDangme dialects is that nasalized [ã] is so high that the plot of nasalized vowels yields a figure quite close to a parallelogram.

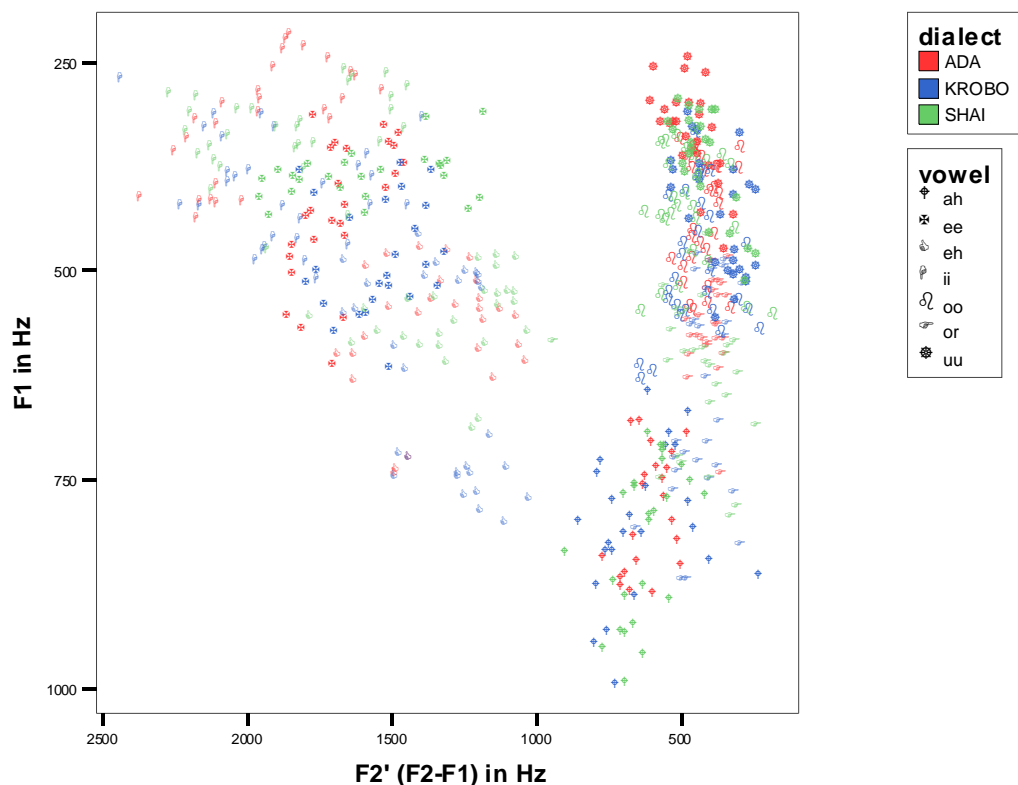


Figure 4.3.4.1 Scatter plot of Dangme oral vowels

4.3.4 Summary of the Dangme Vowels

The oral vowels of the various dialects of Dangme are quite similar to each other except that the vowels of the Krobo dialect of Dangme occupy a wider space, and are generally lower than comparable vowels of the other dialects. Generally, [i] occupies a space slightly higher and more front than [e] and it is slightly higher than the back vowel [u]. [ɛ] and [ɔ] are about the same height generally. They are located around similar levels on the vertical axis, though [ɛ] is a front vowel while [ɔ] is a back one. [a] is generally located slightly more central than [u] and [o]. It is the lowest vowel (i.e. with the largest value on the vertical axis). The vowels of Krobo dialect are slightly lower than the rest of the Dangme dialects.

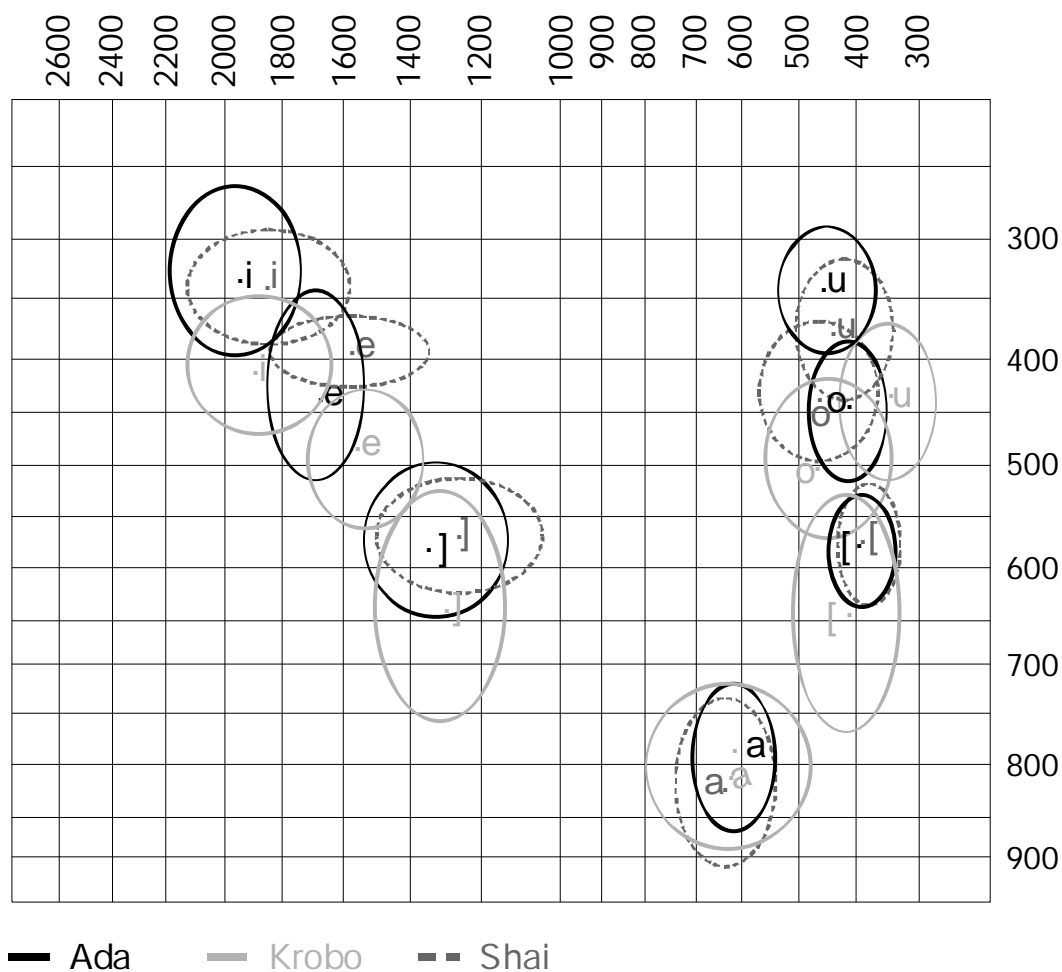


Figure 4.3.4.2 Dangme oral vowel ellipses

Figures 4.3.4.3 and 4.3.4.4 present all twelve vowels for all three Dangme dialects of the study. From the figures, it is clear that there is a systematic relationship between the oral vowels of Dangme and their nasalized cognates. With the exception of the cognate of low vowels, all oral vowels are placed higher on the vowel chart than their nasalized cognates. Oral [i] and [u] are the highest vowels on the chart while oral [a] is the lowest. Nasalized [ɔ̃] is the furthest back of all Dangme vowels.

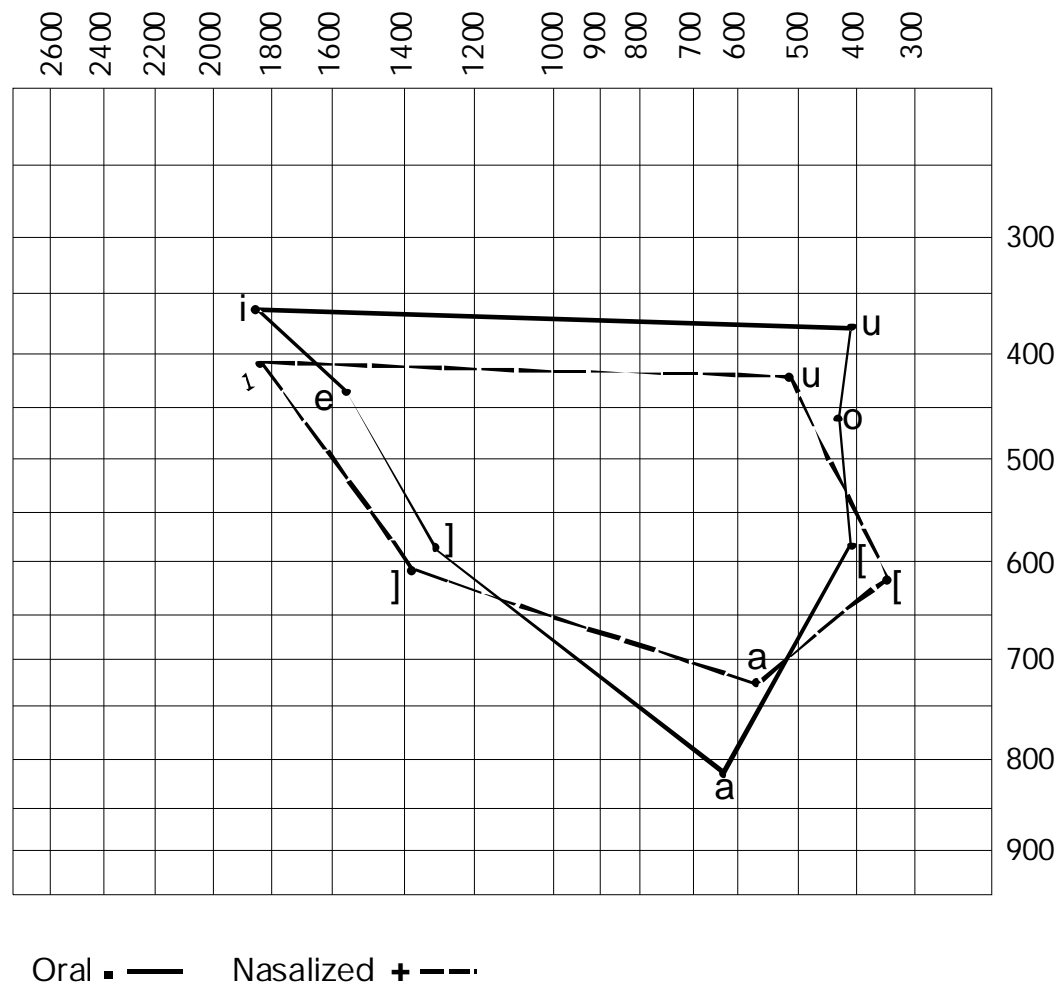


Fig 4.3.4.4 Dangme vowel space

Tables 4.3.4.1 and 4.3.4.2 present results of a one-way analysis of variance and a two-tailed t-test, respectively, performed on the 12 Dangme vowels. The results indicate that while all 12 vowels are significantly different from one another, there are no significant differences between same vowels of the different dialect areas. Nasalized [ũ] seems to show a slight interdependence but nothing significant (0.059 level of significance). Results indicate further that with the exception of the high front cognate vowel pair (0.069 level of significance), the seemingly overlapping vowel pairs are, indeed, significantly different from one another.

Tables 4.3.4.1 Results for Analysis Of Variance across dialects of Dangme language

Paired vowels	F-value	Df	Sig. (2-tailed)
i	0.132	2	0.876
e	0.248	2	0.780
ɛ	0.657	2	0.519
a	0.286	2	0.752
ɔ	0.925	2	0.148
o	1.238	2	0.292
u	0.031	2	0.969
ĩ	0.107	2	0.899
ẽ	0.588	2	0.556
ã	0.158	2	0.854
õ	0.600	2	0.550
ũ	2.874	2	0.059

Table 4.3.4.2 Results of Paired Samples Test for Dangme

Paired vowels	T-value	Df	Sig. (2-tailed)
i/e	8.285	227	0.000
u/o	8.303	224	0.000
i/ĩ	-1.828	194	0.069
ɛ/ẽ	-5.961	242	0.000
a/ã	7.072	209	0.000
ɔ/õ	2.776	221	0.006
u/ũ	-6.386	161	0.000

4.4 Vowels of the GaDangme language area

4.4.1. GaDangme Oral Vowels.

Figure 4.4.1 presents a scatter plot of all 2160 vowel tokens for all 60 speakers of all six dialects of GaDangme. It reveals a rather overcrowded situation – especially among the back vowels. Even in the less crowded front vowel space it is quite difficult to sort out where one vowel ends and another begins. In order to make sense out of the data, it was subjected to the same normalization process used on the data from the individual dialects. In other words, a one-way ANOVA was performed to find out how significantly different or similar comparable vowel sounds across dialects of each language are and then to compare the differences within and between Ga and Dangme. Results of this process are shown on the following pages.

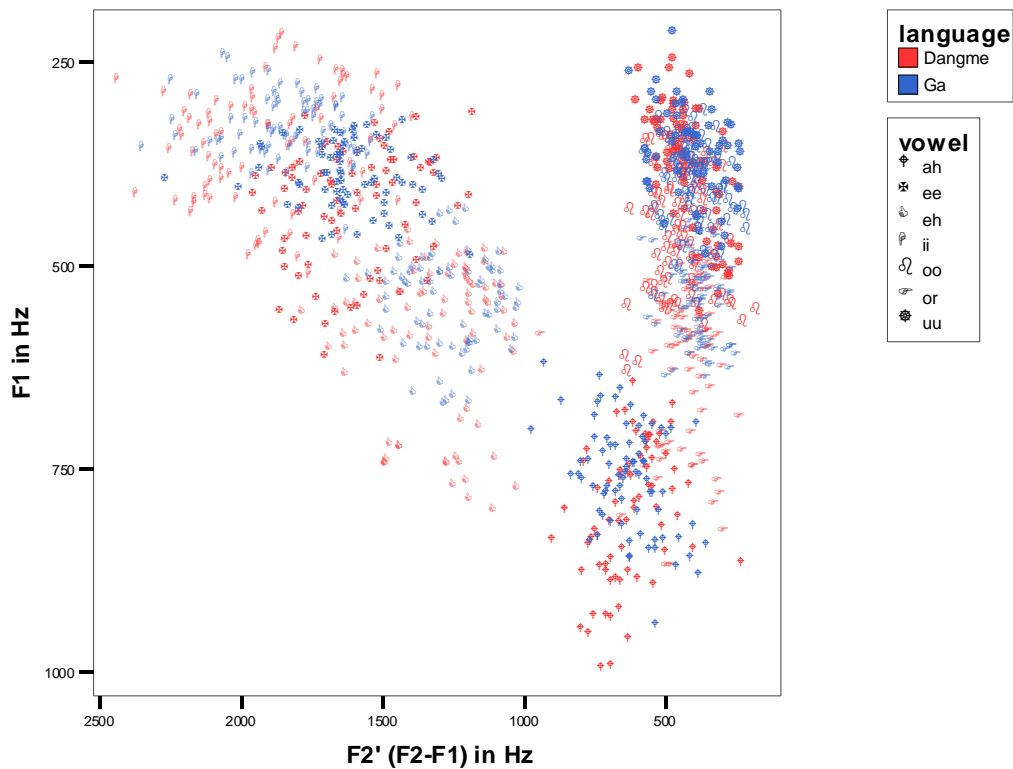


Figure 4.4.1 Scatter plot of GaDangme oral vowels

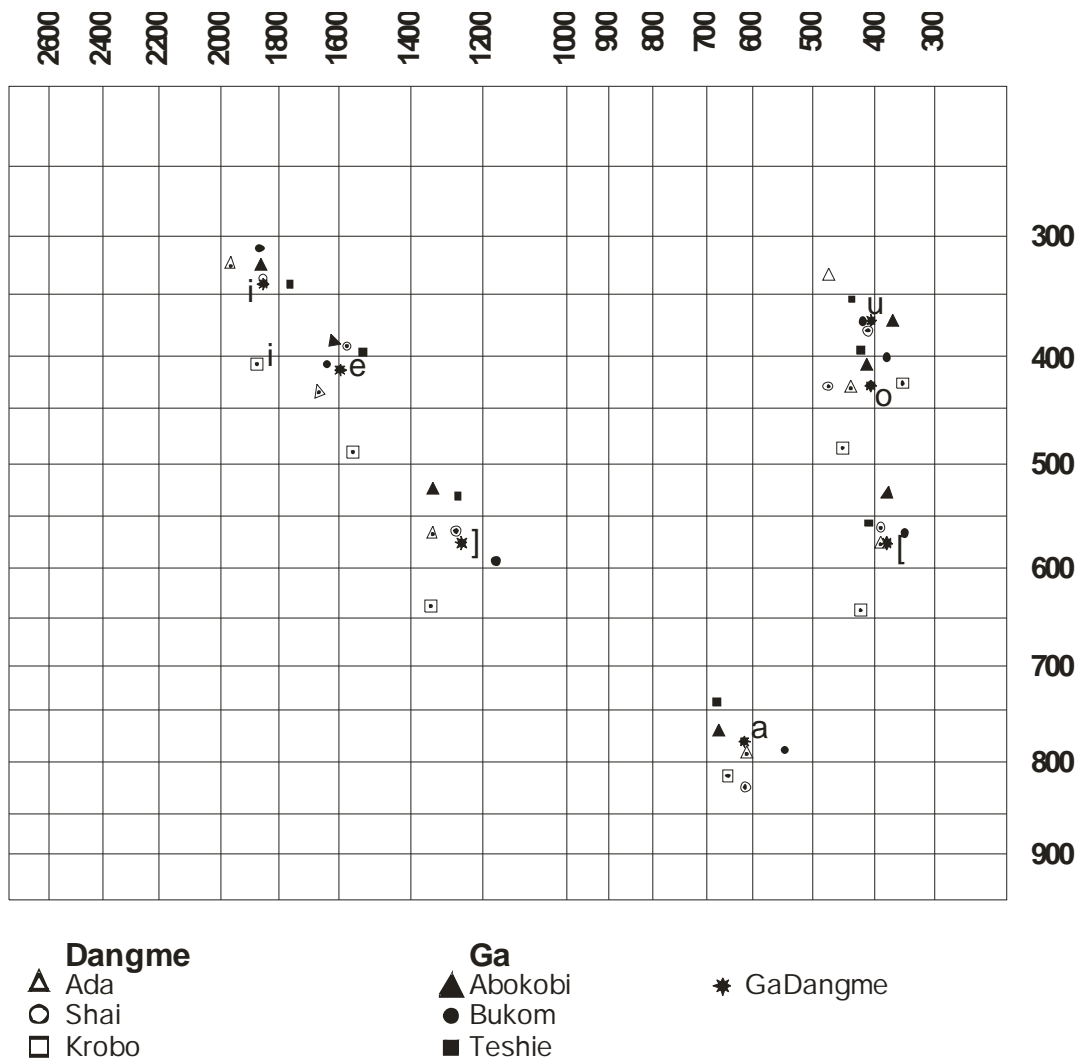


Figure 4.4.2 Plot of the mean values for the oral vowels of all six GaDangme dialects

Figure 4.4.2 presents a plot of the mean values of the oral vowels of all six GaDangme dialects. It is evident from this figure that the vowels of the Krobo dialect of Dangme stand quite apart from the vowels of the other five dialects. It is further evident that the vowels of Shai are closer to the three Ga dialects than those of Ada. Shai and the three Ga dialects tend to cluster around the mean values of GaDangme with Shai being the closest to the GaDangme means. Figure 4.4.3 presents ellipses drawn around the mean values of Ga and Dangme.

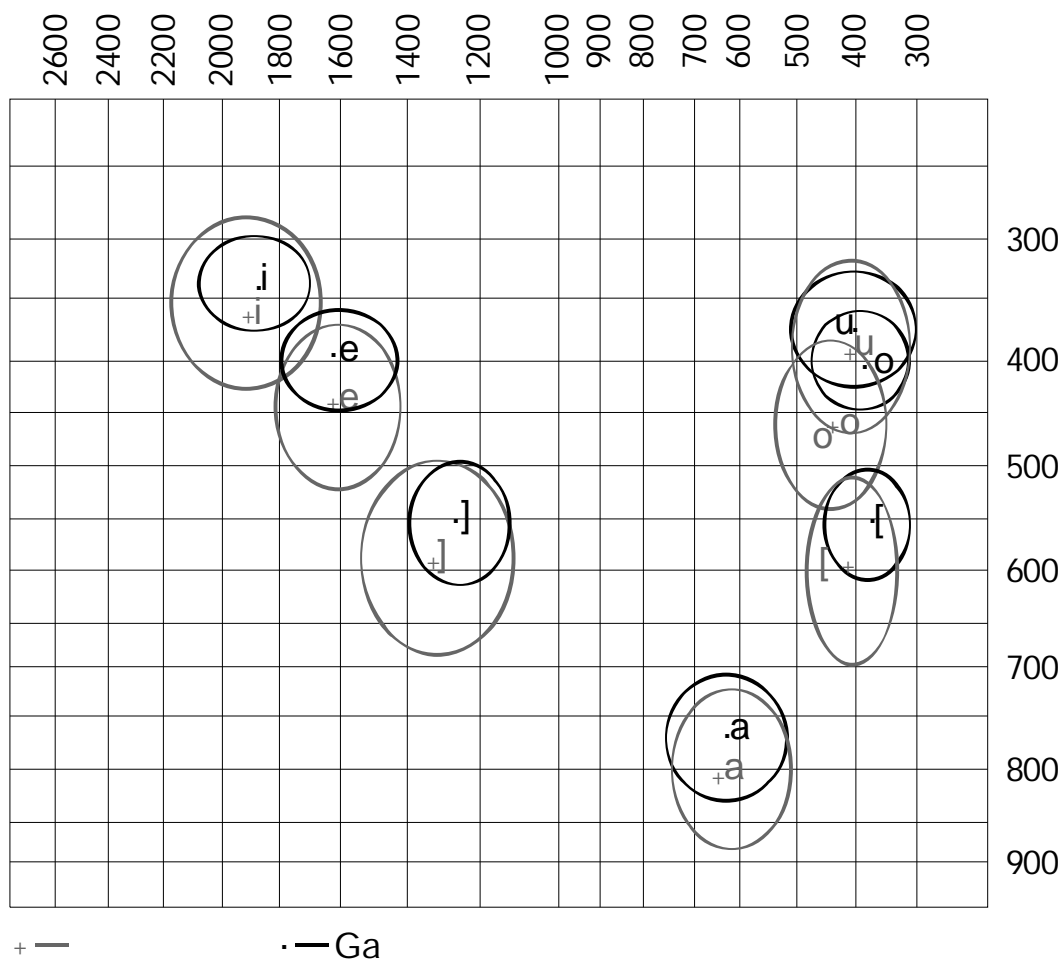


Figure 4.4.3 Ellipses of Ga and Dangme oral vowels

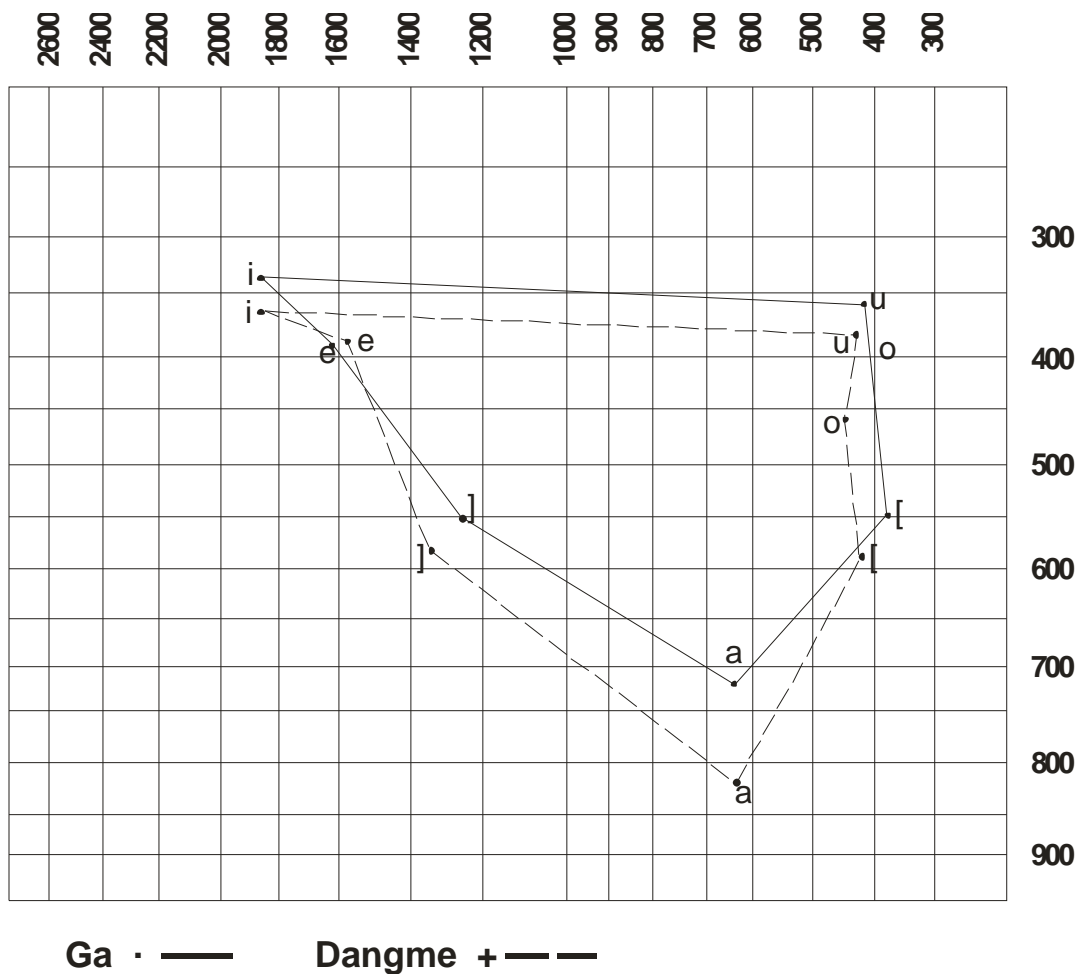


Figure 4.4.4 Ga and Dangme oral vowel chart

Results of the ANOVA show that at a confidence level of 95% apart from [ũ], all the comparable vowel sounds of Ga are not significantly different across the dialects. [ũ] is slightly different at a significant level of 0.074. This shows that the dialects belong to one homogeneous set which is the Ga language. The results for Dangme language are not too different from that of Ga language. Tables 4.4.1 and 4.4.2 show the ANOVA results.

Tables 4.4.1 Results of the Analysis of Variance on the GaDangme Language

Vowels	F_value	Df	Sig. (2_tailed)
i	.434	1	0.510
e	.236	1	0.627
ɛ	1.685	1	0.195
ē	.342	1	0.559
ɔ	3.749	1	0.053
o	12.347	1	0.000
u	1.024	1	0.312
ĩ	1.162	1	0.282
ẽ	1.605	1	0.206
ã	2.344	1	0.127
õ	8.349	1	0.004
ũ	.099	1	0.754

4.4.2 GaDangme Nasalized Vowels

The nasalized vowels of both Ga and Dangme languages seem to shrink the vowel spaces. The highest nasalized vowel in the vowel space [ĩ] is slightly lower than its oral counterpart [i]. It is almost at the height of [e] but more front than [e] and less front than [i]. [ẽ] is more front than its oral counterpart [ɛ]. It is also lower than [ɛ]. [ã], the lowest nasalized vowel in the vowel space is higher than [a] and it is also more back. [õ] is the most back vowel among all the other vowels in the vowel spaces. It is higher than its oral counterpart. [õ] in back is slightly higher than [ẽ] in front of the vowel spaces. [ũ] is the highest nasalized vowel in the vowel spaces of both Ga and Dangme. It is slightly lower and more front than its oral counterpart [u]. The nasalized vowels form a smaller vowel space as compared to the oral vowels. The nasalized vowel space is somehow skewed towards the front of the vowel space such that the front nasalized vowels are more front than their oral counterparts and the back nasalized vowels are less back except for [õ] which is the most back of all the back vowels. The figures below show the ellipses of Ga oral vs. nasalized vowels and Dangme orals vs. nasalized vowels.

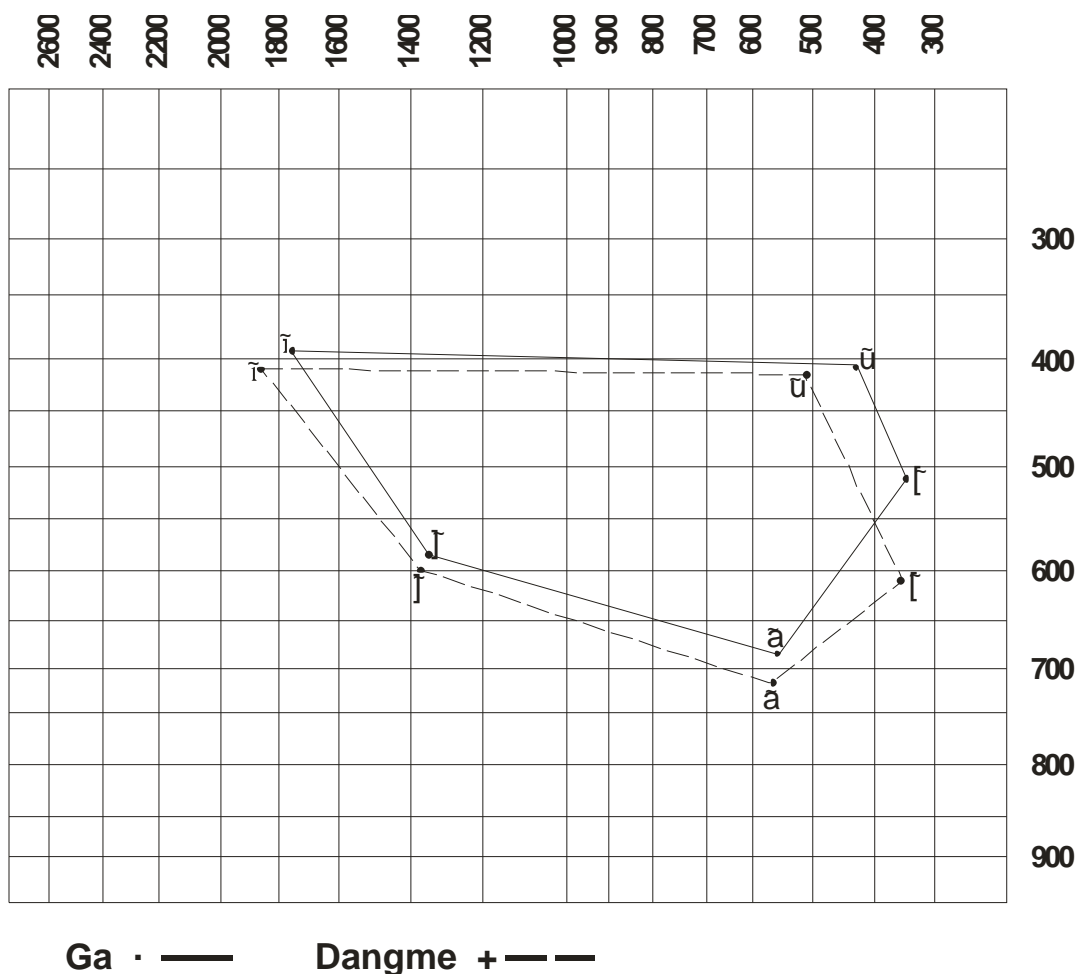


Figure 4.4.5 Ga and Dangme nasalized vowels.

This result proves that with the exception of [o] and [ɔ̃], there are no significant differences between comparable vowel sounds across the Ga and Dangme languages. The difference between the [o] and [ɔ̃] sounds of the two languages is highly significant. This significant difference may be a result of the choice of test words used for the study.

A test for the significant differences between vowel sounds was carried out on the following vowel pairs which were seen to be close in the vowel space: [i/e], [e/ɛ], [u/o], [i/ĩ], [ɛ/ẽ], [a/ã], [ɔ̃/õ], [u/ũ]. The results show that at a confidence level of 95%, all the pairs tested are significantly different except the [i/ĩ], pair for GaDangme which has a significant value of 0.194. Table 4.4.2 above shows the results of the paired samples test. There is a slight interdependence observed in the pair [ɛ/ẽ].

Table 4.4.2 Results of the Paired Samples Test for GaDangme

Paired vowels	T-value	Df	Sig. (2-tailed)
i/e	9.519	296	0.000
e/ɛ	7.516	296	0.000
u/o	3.613	275	0.000
i/ĩ	-1.302	305	0.194
ɛ/ẽ	-2.036	262	0.043
a/ã	9.953	284	0.000
ɔ/o	14.596	299	0.000
ɔ/õ	2.765	299	0.006
u/ũ	-10.799	227	0.000

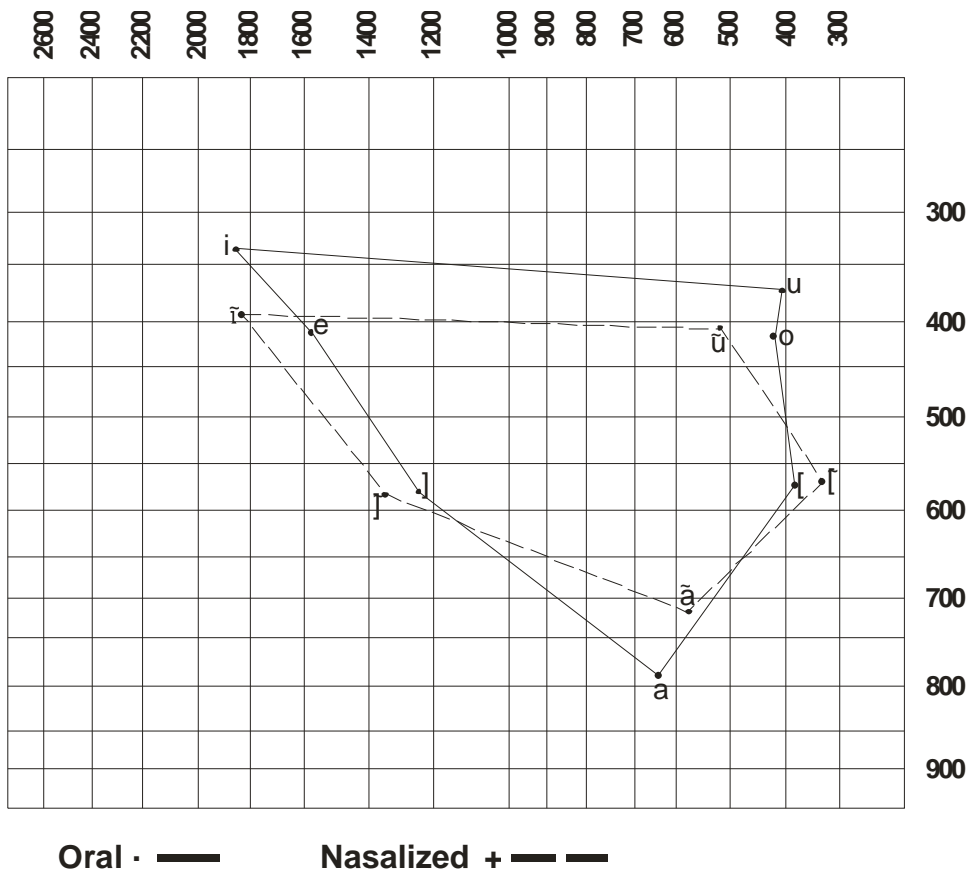


Figure 4.4.6 The GaDangme vowel chart

CHAPTER FIVE: DISCUSSION AND CONCLUSION

5.0 DISCUSSION AND CONCLUSION:

This study has been carried out to determine the acoustic correlates of vowels in GaDangme. The results of the spectrographic analysis performed on the vowels of the various dialects of Ga and Dangme reveal similarities and slight differences between the vowel spaces of the dialects.

5.1 The GaDangme Oral Vowels

Overall, there are four distinct vowel heights as indicated in Table 5.1. For the non-low vowels, the front member (left symbol) of each pair is slightly higher on the acoustic space than the back member (right symbol). Also emerging from the study is a distinct front-back dimension. A third dimension, namely, central is not very apparent. The only vowel in this final category is the low vowel [a]. For most of the dialects of GaDangme, however, this central vowel is quite close in space to the back vowels. (Bukom is a very clear example of this.) This is quite contrary to traditional descriptions of Ga and Dangme [a], which has otherwise been described as a front vowel (Dakubu, 2002 and Apronti, 1967).

A very interesting outcome of the study is the fact the various dialects of GaDangme seem to utilize the same vowel space, with the vowels of Shai being closest to the mean GaDangme values and the vowels of Krobo are the furthest from the mean values. This corresponds to the geographical facts. In reality, the Krobo dialect is located at the northernmost part of the GaDangme geographical area (see Figure 1). Shai, in fact, is spoken around the central part of the GaDangme geographical area. Looked at from a different perspective, it could be stated that the GaDangme vowels form a continuum with the Shai vowels at the middle while those of Krobo, Ada and Bukom form the periphery.

Table 5.1. Summary of GaDangme vowel height versus front-back.

	Front	Central	Back
High:	[i]		[u]
Midle 1:	[e]		[o]
Middle 2:	[ɛ]		[ɔ]
Low:		[a]	

On the individual language levels, the three dialects of Ga, namely, Abokobi, Bukom, and Teshie have been found to have similar vowel spaces in which [i] is located as a high front vowel and is slightly more front and higher than [e]. The sound [e] is very close to [i] in the vowel space without overlapping. [ɛ] is located towards the mid area of the space, about halfway between front and back. [ɛ] is less front than [i] and [e]. It is the lowest vowel in front.

[a] is more of a back vowel for all three dialects with Bukom [a] even more back. [a] is slightly less back than [ɔ], [o], and [u]. It is the lowest vowel in the space. The sound [ɔ] is about the same height as [ɛ] and is slightly more back than [a]. [u] and [o] are located as high and midhigh vowels respectively. The two sounds slightly overlap with [o] slightly more back and slightly lower than [u].

The pattern of oral vowels in the vowel space of Ga language as the study reveals is slightly different from the pattern postulated by some linguists. For instance, Kropp Dakubu places [ɛ] at a more fronted position in the space; this study however reveals a less fronted [ɛ]. In fact [ɛ] is almost a central vowel. [a] is another vowel that is differently represented by the study. In that, whereas most linguists represent [a] as a front vowel, the results of the study show that [a] is actually a back vowel; it is only slightly more front than the other back vowels: [u], [o], and [ɔ].

The formant values of Ga [o] seem to have been affected by the high tone used in the study. The word [bo] is used rather infrequently and the unfamiliarity of most of the people recorded might have been responsible for the overlap between the two sounds. In fact, casual listening by members of the UEW Phonetics Lab indicates that the word is quite close to [bu]. Eric Zee's study (1978) shows that tones affect the formant frequency values of vowels. The pronunciation of [bu] (to wear) and [bo] (to soften) is not easily differentiated when perceived, probably because of the choice of words used.

The pattern of vowels in the Dangme vowel space as indicated by the study is almost similar to what the impressionistic presentation of the vowel space by Apronti shows; there are slight differences though. This study reveals a less fronted [ɛ] sound than what is presented by Apronti. The study shows Dangme [ɛ] sound to be almost a central vowel just like the Ga [ɛ].

As discussed earlier, this study indicates that [a] is more of a low back vowel than it is a front one. Since the symbol [a] is used by the International Phonetic Association (IPA) table to represent a low front vowel, the most appropriate IPA symbol that must be used in transcribing the low back vowel of Dangme and Ga languages is [ɑ] rather than [a].

5.2 The GaDangme Nasalized Vowels

The nasalized vowels in both Ga and Dangme as the study shows are not in conformity with what is shown in either Dakubu Kropp's or Apronti's representations of the vowel chart. The two linguists portray the nasalized vowels as the higher members of the oral-nasalized cognate pairs. For instance, [ĩ] is said to be the higher and less fronted nasalized counterpart of [i], but this study yielded opposite results, showing the sound [ĩ] rather as lower and more fronted than [i]. Similarly, the nasalized counterpart of [ɛ] is represented as the higher and less front member of the pair, whereas this study shows that the nasalized counterpart is rather lower and slightly more fronted than the oral [ɛ].

For both Ga and Dangme, [ã] is slightly higher and more back than its oral counterpart just like what is postulated in the literature. The study shows further that the nasalized counterpart of [ɔ] is slightly higher than the oral and it is the most back vowel in the space for both Ga and Dangme. [ũ] is located slightly lower and more front than [u]. [ũ] is about the same height as [ĩ].

A very interesting finding is that in both Ga and Dangme, nasalized [ɔ̃] is the most back vowel. Also, the nasalized vowels seem to shrink the vowel space while the oral vowels enlarge the space.

5.3 CONCLUSION

In conclusion, the vowels of Ga and Dangme form very similar vowel spaces except that Ga vowels are more compact. This slight difference might be a result of the vast nature of the Dangme speaking area (which is three times as large as the Ga area), meaning that, but for the difference in the sizes of space occupied, Ga and Dangme have basically the same set of vowels. The results are suggestive of the fact that Ga and Dangme belong to one mother language. The nature of that mother language is subject to more investigation.

Thus far, it is clear that GaDangme has three front vowel phonemes and four back vowel phonemes. The front vowels are [i], [e], [ɛ] and the back vowels are [u], [o], [ɔ], [a]. The language has 5 nasalized vowel sounds including [ĩ], [ẽ], [ã], [ɔ̃], [ũ]. The arrangement of vowels in the vowel space of the language is such that the oral vowels enlarge the space while the nasalized vowels shrink it. The oral vowels are in the periphery as far as height of the space (the vertical axis) is concerned. On the front/back dimension, the nasalized vowel space is skewed towards the front except for [ɔ̃] which is the most back vowel so that [ĩ] and [ẽ] are more front than [e] and [ɛ] while [ũ] is more front than [u].

The high vowels [i] and [u] are very close to the vowels [e] and [o] to the extent that their ellipses almost touch each other. This revelation is made clear when one listens to native speakers produce [i] or [e] and [u] or [o] with the high tone in words or syllables.

An ongoing research aims to find out the effect of the three tones on the GaDangme vowels. Meanwhile, the projection is that these will affect vowel quality in some systematic ways. Hopefully, the combination of the present results and the forthcoming study on tones will help end the current rage on the alphabetic representation of vowels of Ga and Dangme.

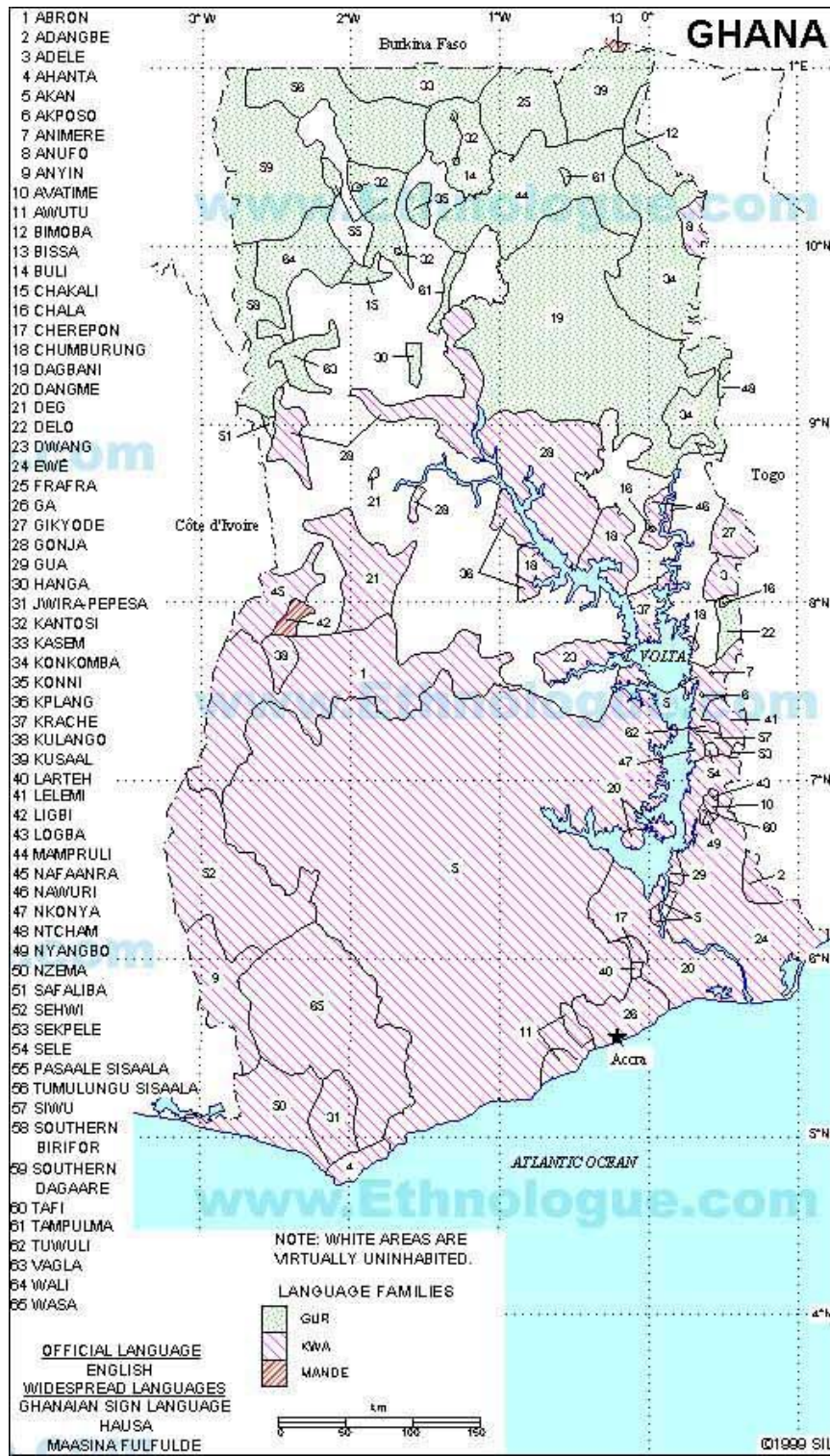
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APPENDIX A: LANGUAGE MAP OF GHANA



APPENDIX B: FORMANT FREQUENCY VALUES

Ga1:Abokobi Speakers	Vowel i	Token 1			Token 2			Token 3		
		F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1		280	2073	1793	276	2065	1989	340	2041	1700
2		351	2421	2070	350	2408	2058	359	2251	1892
3		359	2701	2342	367	2383	2016	366	2268	1902
4		362	2281	1919	346	2567	2221	336	2187	1851
5		291	2165	1874	280	2132	1852	304	2162	1858
6		353	2048	1695	321	2057	1736	342	1968	1626
7		558	1907	1349	522	2032	1510	473	2005	1532
8		393	2344	1951	363	2314	1951	309	1966	1657
9		389	2283	1894	346	2175	1829	337	2210	1873
10		347	2145	1798	307	1964	1657	299	2165	1866
	e									
1		367	2012	1645	341	1985	1644	404	1936	1532
2		411	2046	1635	430	2260	1830	434	2226	1792
3		397	2659	2262	392	2029	1637	418	2032	1614
4		414	2067	1653	466	2045	1580	391	2094	1703
5		400	2040	1640	423	2066	1643	401	2057	1656
6		338	1935	1597	403	1827	1424	361	1929	1568
7		567	1718	1153	551	1834	1283	536	1778	1242
8		406	1962	1556	357	1989	1632	329	1328	999
9		338	2002	1664	358	2064	1706	353	1980	1627
10		332	1880	1548	344	1860	1516	325	1752	1427
	ɛ									
1		609	1802	1193	528	1932	1404	537	1850	1313
2		672	1862	1190	606	1969	1363	674	1955	1281
3		574	1946	1372	564	1890	1326	519	1945	1426
4		543	2026	1483	516	2059	1543	521	2145	1624
5		505	1892	1387	513	1801	1288	479	1911	1432
6		514	1806	1292	495	1817	1322	517	1771	1254
7		698	1698	1000	745	1655	910	749	1682	933
8		514	1703	1189	490	1806	1316	506	1611	1105
9		578	1931	1353	514	1914	1400	509	1865	1356
10		442	1733	1291	450	1686	1236	436	1638	1202
	a									
1		842	1348	506	785	1290	505	748	1320	572
2		947	1480	533	755	1386	631	810	1538	728
3		746	1543	797	745	1513	768	708	1680	972
4		626	1554	928	812	1527	715	763	1566	803
5		770	1330	560	748	1361	613	725	1348	623
6		717	1296	579	674	1410	736	745	1379	634
7		836	1419	583	760	1358	598	785	1327	542
8		847	1468	621	864	1488	624	768	1415	647
9		765	1426	661	787	1499	712	865	1487	622
10		702	1247	545	668	1342	674	701	1335	634

Ga1:Abokobi	Vowel	Token 1			Token 2			Token 3		
Speakers	ɔ	F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1		520	866	346	536	811	275	545	852	307
3		592	1043	451	596	1023	427	547	984	401
4		489	886	397	499	901	402	499	904	405
5		555	864	309	526	893	367	626	977	351
6		582	962	380	590	983	393	526	963	437
7		760	1164	404	717	1270	553	705	1171	466
8		518	994	476	525	951	426	518	949	431
9		532	841	309	482	894	412	535	848	313
10		458	884	426	462	790	328	449	864	415
o										
1		376	642	266	373	707	334	356	770	414
2		422	757	335	385	791	406	385	837	452
3		446	936	490	443	966	523	396	854	458
4		431	662	231	458	677	219	442	657	215
5		410	721	311	406	702	296	424	706	282
6		422	835	413	375	852	477	413	847	434
7		540	1081	541	504	977	473	503	958	455
8		396	894	498	372	842	470	337	794	457
9		319	846	527	349	828	479	339	838	499
10		390	758	368	400	792	392	350	770	420
u										
1		365	601	236	314	649	335	407	653	246
2		368	810	442	436	680	244	452	957	505
3		409	963	554	436	1171	735	388	848	460
4		364	678	314	428	555	127	429	520	91
5		330	607	277	290	630	340	332	599	267
6		365	789	424	339	749	410	379	693	314
7		542	889	347	552	857	305	483	786	303
8		305	771	466	346	738	392	372	797	425
9		464	1529	1065	345	730	385	340	760	420
10		445	831	386	514	3484	2970	351	649	298
ĩ										
1		298	1989	1691	293	2100	1807	302	2013	1711
2		393	3280	2887	400	2250	1850	348	2420	2072
3		431	2159	1728	386	2220	1834	411	2225	1814
4		485	2361	1876	549	2689	2140	561	2160	1599
5		297	3850	3553	359	3626	3267	430	2434	2004
6		343	2062	1719	469	2212	1743	360	2346	1986
7		500	2890	2390	517	2113	1596	493	2155	1662
8		307	2100	1793	430	2019	1589	254	2011	1757
9		418	2962	2544	423	2777	2354	393	2115	1722
10		297	1978	1681	365	2235	1870	331	1826	1495

Ga1:Abokobi	Vowel	Token 1			Token 2			Token 3		
Speakers	ẽ	F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1		546	1628	1082	565	1651	1086	553	1778	1225
2		497	1879	1382	544	1678	1134	521	1734	1213
3		632	1912	1280	799	2048	1249	521	1915	1394
4		711	1849	1138	595	1925	1330	693	1229	536
5		602	1749	1147	483	1665	1182	687	1539	852
6		579	1775	1196	586	1746	1160	648	1649	1001
7		736	1965	1229	739	2036	1297	651	1947	1296
8		528	1840	1312	506	1861	1355	468	1908	1440
9		581	2111	1530	548	2216	1668	476	2092	1616
10		401	1804	1403	410	1940	1530	412	1891	1479
	ã									
1		676	1098	422	636	1147	511	645	1153	508
2		474	1297	823	654	1303	649	508	1365	857
3		644	1036	392	567	1066	499	585	1404	819
4		872	1139	267	787	1022	235	838	1142	304
5		778	1290	512	740	1294	554	423	1265	842
6		706	1243	537	692	1198	506	676	1255	579
7		785	1305	520	718	1255	537	858	1196	338
8		687	1391	704	645	2539	1894	995	1961	366
9		403	1586	1183	543	1203	660	775	1374	599
10		472	1011	739	523	1162	639	840	2820	1980
	õ									
1		586	896	310	538	847	309	554	758	204
2		537	1050	513	550	1042	492	691	989	298
3		553	992	439	699	1026	327	556	919	363
4		671	864	193	542	799	257	622	780	158
5		665	838	173	585	2739	2154	585	814	229
6		552	881	329	577	724	147	565	790	225
7		719	987	268	641	988	347	475	1480	1005
8		454	912	458	498	968	470	430	896	466
9		406	715	309	460	706	246	463	812	349
10		347	1030	683	275	831	556	386	720	334
	ü									
1		327	2660	2333	320	1251	931	411	956	545
2		429	3042	2613	426	2981	2555	384	749	365
3		412	934	522	414	915	501	402	735	333
4		224	1170	946	259	2844	2585	495	996	501
5		360	770	410	503	2179	1676	334	2667	2333
6		485	1113	628	347	886	539	412	809	397
7		669	3674	3005	508	804	296	486	955	469
8		329	660	331	377	780	403	363	735	372
9		484	1367	883	570	2875	2305	590	2417	1827
10		389	1305	916	717	1628	911	329	627	298

Ga2: Bukom Speakers	Vowel	Token 1			Token 2			Token 3		
		F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1	i	366	2082	1716	412	2159	1747	343	2134	1791
2		323	2300	1977	336	2228	1892	343	2338	1995
3		249	2284	2035	277	2519	2242	243	2300	2057
4		285	3029	2744	269	2737	2468	300	2198	1898
5		321	1850	1529	315	1832	1517	303	1726	1423
6		355	2109	1754	321	1953	1632	386	1981	1595
7		326	2561	2235	294	2440	2146	266	2215	1949
8		324	2350	2026	310	2185	1875	292	2067	1775
9		412	2192	1780	410	2196	1786	357	2178	1821
10		304	2072	1768	333	2007	1674	302	2056	1754
	e									
1		359	2277	1918	347	1942	1595	429	2055	1626
2		338	2490	2152	408	2410	2002	404	2193	1789
3		416	1899	1483	448	1977	1529	411	1764	1353
4		384	2315	1931	341	2186	1845	354	2281	1927
5		347	1830	1483	329	1709	1380	446	1820	1374
6		394	1593	1199	375	1650	1275	374	1685	1311
7		505	2223	1718	466	2141	1675	427	2062	1635
8		573	1968	1395	543	1996	1453	527	2033	1506
9		473	2181	1708	431	2104	1673	407	2676	2269
10		405	1790	1385	443	1795	1352	427	1917	1490
	ɛ									
1		514	2088	1574	529	1681	1152	512	1619	1107
2		605	1941	1336	660	2046	1386	599	1788	1189
3		595	1778	1183	613	1823	1210	600	1782	1182
4		507	2020	1513	490	2036	1546	491	2073	1582
5		414	1426	1012	488	1570	1082	551	1564	1013
6		507	1622	1115	543	1604	1061	512	1591	1079
7		672	1938	1266	715	1853	1138	648	1939	1291
8		892	1819	927	807	1902	1095	715	1784	1069
9		601	1022	1421	665	1910	1245	601	1893	1292
10		606	1849	1243	610	1646	1036	593	1622	1029
	a									
1		863	1271	408	905	1388	483	841	1290	449
2		918	1387	2305	855	1387	532	854	1409	555
3		820	1511	691	824	1476	652	838	1570	732
4		677	1292	615	734	1451	717	652	1041	389
5		692	1266	574	722	1287	565	616	1219	603
6		706	1217	511	699	1084	385	705	1179	474
7		750	1447	697	696	1516	820	768	1558	790
8		899	1308	409	885	1264	379	849	1203	354
9		825	1225	400	807	1400	593	816	1880	1064
10		875	1336	461	808	1330	522	746	1320	574

Ga2: Bukom	Vowel	Token 1			Token 2			Token 3		
Speakers	ɔ	F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1		548	923	375	517	873	356	510	880	370
2		603	869	266	588	959	371	606	965	359
3		594	961	367	631	904	273	609	901	292
4		476	895	419	485	836	351	458	806	348
5		568	919	351	521	907	386	510	880	270
6		535	924	389	521	894	373	554	935	381
7		675	1003	328	547	920	373	557	995	438
8		849	1145	296	808	1111	303	723	999	276
9		643	1003	360	661	884	223	627	967	340
10		614	1028	414	601	971	370	604	872	268
	o									
1		412	839	417	380	784	404	437	815	378
2		373	693	320	421	741	320	384	765	381
3		615	807	192	566	754	188	557	767	210
4		355	705	350	379	739	360	311	680	369
5		333	658	325	335	742	407	338	764	426
6		371	782	411	374	770	396	378	740	362
7		490	795	305	459	632	173	447	733	286
8		618	985	367	581	1038	457	555	1079	524
9		487	854	367	492	820	328	450	830	380
10		418	928	510	441	795	354	413	824	411
	u									
1		421	2266	1845	407	743	336	402	966	564
2		542	3291	2749	594	1444	850	533	2064	1531
3		300	738	438	673	2995	2322	713	2283	1570
4		492	1948	1456	357	635	278	331	2433	2102
5		375	941	566	443	833	390	304	745	441
6		361	935	574	342	766	424	341	2248	1907
7		359	751	392	291	751	460	333	679	346
8		290	839	549	300	832	532	293	1016	723
9		503	887	384	490	848	358	469	759	290
10		700	1108	408	393	758	365	450	754	304
	ĩ									
1		461	2169	1708	491	2071	1580	479	2101	1622
2		442	2642	2200	415	2864	2449	371	2413	2042
3		400	2262	1862	610	2328	1718	356	2283	1927
4		265	2416	2151	462	2364	1902	472	2267	1795
5		350	1724	1374	333	1659	1326	317	1725	1408
6		323	2187	1864	359	2231	1872	400	2063	1663
7		281	2115	1834	281	1694	1413	474	1885	1411
8		372	2368	1996	331	2190	1859	301	2129	1828
9		549	2322	1773	480	2228	1748	497	2295	1798
10		274	1933	1659	399	2178	1779	331	2056	1725

Ga2: Bukom	Vowel	Token 1			Token 2			Token 3		
Speakers	ɛ	F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1		657	1682	1025	594	1697	1103	602	1679	1077
2		696	2157	1462	637	2043	1406	659	2027	1368
3		623	1958	1335	640	2011	1371	696	1848	1152
4		531	2215	1684	528	2156	1628	477	2204	1727
5		365	1731	1366	367	1769	1402	429	1770	1341
6		570	1750	1180	541	1034	493	506	1747	1241
7		548	2128	1580	593	2261	1668	592	2232	1640
8		843	2071	1228	806	2170	1364	724	2151	1427
9		672	2257	1585	665	2174	1509	595	2134	1539
10		658	1949	1291	651	1982	1331	652	1980	1328
	ǣ									
1		877	1157	280	800	1163	363	827	1129	302
2		773	1434	661	788	1370	582	737	1365	628
3		854	1501	647	661	1745	1084	778	1409	631
4		631	1233	602	633	1201	568	621	1152	531
5		550	1106	556	652	1106	454	589	1075	486
6		717	1070	353	564	1052	488	638	1136	498
7		789	1599	810	683	1417	734	724	1504	780
8		916	1512	596	912	1394	482	811	1366	555
9		698	1224	526	718	1254	536	707	1360	653
10		798	1296	498	862	1198	336	850	1163	313
	ɔ									
1		557	1608	1051	670	2508	1838	786	2484	1698
2		483	802	319	506	728	222	511	837	326
3		548	862	314	649	1064	415	534	1004	470
4		444	839	395	503	771	268	427	766	339
5		417	719	302	440	736	296	483	813	330
6		486	785	299	514	786	272	502	772	270
7		449	877	428	482	745	263	588	2976	2388
8		728	1040	312	679	1014	335	580	927	347
9		553	959	406	672	1010	338	580	929	349
10		639	871	232	596	779	183	612	877	265
	ũ									
1		442	933	491	452	1077	625	442	1076	634
2		503	1357	854	507	1380	873	415	1327	912
3		424	1016	592	540	2968	2428	497	1195	698
4		513	2501	1988	361	1142	781	441	2822	2381
5		464	830	366	419	1079	660	497	804	307
6		415	2463	2048	375	3163	2788	437	2451	2014
7		349	770	421	360	1845	1485	269	1980	1711
8		675	1452	777	495	2636	2141	384	1664	1280
9		395	980	585	407	928	521	432	930	498

10 662 2832 2170 551 2774 2223 2103 2842 739

Ga3:Teshie Speakers	Vowel	Token 1			Token 2			Token 3		
		F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1	i	369	1915	1546	353	1883	1530	344	1931	1587
2		385	2140	1755	461	2083	1622	391	2222	1831
3		286	2007	1721	304	2029	1725	301	2009	1708
4		372	2434	2062	365	2515	2150	353	2454	2101
5		363	1949	1586	383	1978	1595	358	1961	1603
6		329	2267	1938	374	2251	1857	342	2224	1882
7		313	2045	1732	307	2019	1712	298	1930	1632
8		316	2086	1770	364	2115	1751	315	2070	1755
9		344	2180	1836	264	2155	1891	276	2286	2010
	e									
1		397	1837	1440	373	1763	1390	362	1827	1465
2		471	1908	1437	456	1926	1470	442	1929	1487
3		369	2013	1644	372	2050	1678	393	1689	1296
4		412	2105	1693	390	2077	1687	405	2188	1783
5		451	1768	1317	398	1683	1285	491	1675	1184
6		398	1918	1520	388	2030	1642	376	2022	1646
7		366	1949	1583	334	1926	1592	351	2020	1669
8		348	2162	1814	336	2191	1855	353	2068	1715
9		369	2074	1705	337	2120	1783	369	2054	1658
	ɛ									
1		569	1516	947	534	1546	1012	558	1646	1088
2		579	1785	1206	634	1812	1178	565	1693	1128
3		498	1623	1125	486	1673	1187	496	1846	1350
4		558	2041	1483	525	2009	1484	583	2080	1497
5		567	1685	1118	556	1575	1019	529	1607	1078
6		526	1878	1352	438	1693	1255	526	1852	1326
7		598	1758	1160	583	1672	1089	551	1637	1086
8		523	1666	1143	507	1763	1256	537	1616	1079
9		526	1942	1416	496	1933	1437	513	1966	1453
	a									
1		793	1444	651	726	1399	673	845	1378	533
2		778	1478	700	777	1531	754	845	1608	763
3		749	1352	603	738	1328	590	777	1434	657
4		908	1606	698	914	1722	808	762	1590	828
5		713	1208	495	704	1292	588	656	1312	656
6		760	1401	641	783	1488	705	689	1433	744
7		786	1335	549	763	1353	590	783	1458	675
8		726	1417	691	640	1371	731	666	1388	722
9		719	1422	703	673	1537	864	718	1464	746
	ɔ									
1		532	935	403	535	890	355	542	909	367
2		641	1138	497	579	1111	532	635	1104	469
3		614	867	253	598	937	339	505	868	363

4		573	942	369	514	956	442	573	961	388
5		571	1129	558	541	1048	507	586	1030	444
6		594	1016	422	557	979	422	551	960	409
7		598	975	377	608	986	378	608	938	330
8		477	929	452	473	1057	584	475	1021	546
9		538	812	274	468	795	327	505	842	337
	o									
1		387	793	406	395	803	408	378	769	391
2		457	961	504	448	961	513	438	1026	588
3		381	745	364	343	719	376	458	802	344
4		409	766	357	356	750	394	432	851	419
5		362	941	579	480	924	444	432	974	542
6		387	838	451	408	707	299	371	795	424
7		391	839	441	372	835	463	458	487	389
8		359	798	439	344	782	438	390	893	503
9		313	745	432	322	727	405	434	695	261
	u									
1		399	685	286	344	744	400	384	631	247
2		264	893	629	276	809	533	339	862	523
3		355	594	239	353	830	477	356	664	308
4		462	845	383	392	777	385	415	867	452
5		366	926	560	370	904	534	401	964	563
6		476	613	137	555	1413	858	0	0	0
7		355	729	374	364	703	339	319	778	459
8		318	813	495	346	809	463	335	1209	874
9		389	511	122	215	689	474	410	651	241
	ĩ									
1		428	1945	1517	404	1991	1587	396	1991	1598
2		367	2030	1663	309	1869	1560	455	1873	1418
3		887	2273	1386	0	0	0	0	0	0
4		329	2287	1958	454	2298	1844	401	2205	1804
5		379	2477	2098	422	1867	1445	410	3765	2355
6		437	2117	1680	435	1968	1533	387	1928	1541
7		391	2125	1734	362	2040	1678	333	1777	1444
8		347	1042	695	390	929	539	320	912	592
9		357	2169	1812	370	2099	1729	371	2127	1756
	ẽ									
1		541	1603	1062	481	1829	1348	467	1472	1005
2		675	1793	1118	671	1866	1195	677	1815	1138
3		613	1707	1088	549	1725	1176	583	1639	1056
4		490	1949	1459	392	1757	1365	431	1700	1269
5		595	1581	986	650	2207	1559	558	1446	888
6		665	2097	1432	614	1774	1160	680	2013	1333
7		554	1748	1194	612	1804	1192	593	1668	1075
8		530	1904	1374	515	1873	1358	488	1986	1498
9		561	1912	1351	488	2054	1566	521	2040	1519
	ã									
1		577	1144	567	655	1203	548	646	1193	547
2		752	1203	451	732	1428	696	703	1347	644
3		770	1175	405	771	1093	322	784	1198	414

4	756	1248	492	837	1236	399	1027	1760	733
5	766	1410	644	727	1262	535	495	1228	733
6	644	1176	532	718	1231	513	583	1141	558
7	685	1279	594	656	1213	557	707	1236	529
8	567	1204	637	607	1071	464	589	1149	560
9	543	1365	822	-	-	-	452	1115	663

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1	522	809	287	507	903	396	517	874	357
2	228	1117	889	231	868	637	246	848	602
3	335	698	363	491	720	229	515	824	309
4	484	831	347	514	810	296	505	737	232
5	555	1073	518	561	1059	498	562	1055	493
6	275	895	620	531	1767	1236	458	710	252
7	491	836	345	549	855	306	486	898	412
8	480	906	426	514	962	448	482	1092	610
9	387	670	283	422	710	288	490	759	269

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1	348	1270	922	-	-	-	-	-	-
3	287	943	656	266	1042	776	298	969	671
4	354	1162	808	383	823	440	431	1192	761
5	412	1096	684	350	738	388	382	740	358
6	323	1034	711	324	771	447	338	972	634
7	359	898	539	360	1001	641	452	795	343
8	432	880	448	448	1066	618	404	763	359

Dangme 1:Ada Vowel		Token 1			Token 2			Token 3		
Speakers	i	F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1		376	1798	1422	375	1753	1378	363	1863	1500
2		238	2105	1867	226	2084	1858	235	2031	1794
3		299	1963	1664	323	2029	1706	313	2035	1722
4		260	2162	1902	251	1962	1711	220	2064	1844
5		265	1898	1633	272	1889	1617	288	1816	1528
6		289	2245	1956	314	2265	1951	299	2246	1947
7		302	2378	2076	361	2608	2247	327	2426	2099
8		416	2782	2366	424	2521	2097	421	2428	2007
9		323	2496	2173	346	2544	2198	419	2536	2117
10		400	2501	2101	422	2579	2157	440	2607	2167
e										
1		375	1827	1452	349	1853	1504	356	1844	1488
2		405	1919	1514	358	2062	1704	319	2088	1769
3		425	2081	1656	352	2042	1690	359	2008	1649
4		280	2088	1808	-	-	-	256	1997	1741
5		388	1868	1480	330	1849	1519	340	1810	1470
6		462	2118	1656	444	2147	1703	399	2080	1681
7		449	2171	1672	439	2232	1793	432	2207	1775
8		572	2380	1808	482	2410	1928	506	2349	1843
9		616	2319	1703	558	2418	1860	562	2222	1660
10		473	2312	1839	487	2332	1845	468	2229	1761
ɛ										
1		633	1779	1146	598	1793	1195	563	1744	1181
2		538	1730	1192	516	1716	1200	490	1713	1223
3		516	1841	1325	479	1779	1300	550	1740	1191
4		484	1991	1507	476	1874	1398	538	1898	1360
5		550	1670	1120	593	1650	1057	560	1627	1067
6		611	1644	1033	556	1959	1403	546	1928	1273
7		499	2081	1582	585	2072	1587	547	2049	1502
8		820	2250	1430	742	2222	1480	726	2161	1435
9		814	2219	1405	831	2198	1367	746	2236	1490
10		605	2290	1685	604	2231	1627	636	2264	1628
a										
1		775	1329	554	827	1335	508	743	1287	544
2		890	1486	596	674	1494	820	750	1373	623
3		740	1324	584	684	1323	639	699	1177	478
4		804	1330	526	723	1252	529	754	1312	558
5		761	1389	628	709	1306	597	685	1351	666
6		882	1590	708	853	1506	653	821	1480	659
7		921	1591	670	947	1612	665	749	1050	301
8		857	1353	496	848	1615	767	835	1233	398
10		873	1577	704	889	1560	671	866	1555	689

Dangme 1:Ada Vowel		Token 1			Token 2			Token 3		
Speakers	ɔ	F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1		586	1009	423	605	956	351	594	1004	410
2		488	825	337	493	892	399	493	885	392
3		516	886	370	521	881	360	517	906	389
4		534	878	344	535	906	371	529	917	388
5		590	999	409	569	943	374	568	946	378
6		582	1045	463	559	994	435	563	1045	482
7		622	991	369	606	1078	472	583	1023	440
8		729	1019	290	747	1112	365	789	1084	295
9		813	1390	577	834	1237	403	804	1300	496
10		633	1109	476	587	960	373	586	939	353
	o									
1		412	780	368	407	810	403	381	848	467
2		379	753	374	367	796	429	354	803	449
3		345	848	503	367	845	478	356	813	457
4		385	803	418	381	681	300	356	655	299
5		378	761	383	403	792	389	424	796	372
6		546	1015	469	490	1020	530	488	954	466
7		459	848	389	462	926	464	455	913	458
8		522	932	410	541	952	411	547	876	329
9		646	1063	417	550	1008	458	519	1013	494
10		469	907	438	500	992	492	477	894	417
	u									
1		343	826	483	366	857	491	304	733	429
2		0	0	0	268	683	415	334	726	392
3		301	908	607	326	896	570	328	866	538
4		249	725	476	260	853	593	261	746	485
5		319	757	438	302	773	471	378	779	401
6		349	792	443	364	804	440	303	821	518
7		326	843	517	313	865	552	325	850	525
8		437	755	318	477	830	353	399	767	368
10		377	741	364	435	869	434	361	812	451
	ĩ									
1		381	1912	1531	356	2169	1813	379	1905	1526
2		297	2078	1781	262	2105	1843	258	2081	1823
3		0	0	0	0	0	0	0	0	0
4		291	2079	1788	285	2007	1722	376	2060	1684
5		337	2124	1787	332	2020	1688	319	2077	1758
6		362	2202	1876	342	2184	1842	322	2206	1884
7		351	2657	2306	402	2494	2092	368	2568	2200
8		403	2671	2268	398	2453	2055	343	2615	2272
9		373	2438	2065	485	2433	1948	487	2457	1970
10		379	2616	2237	384	2633	2249	352	2685	2333

Dangme 1:Ada Vowel		Token 1			Token 2			Token 3		
Speakers	ɛ	F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1		608	1489	881	579	1693	1114	543	1759	1216
2		600	1747	1147	601	1890	1289	-	-	-
3		493	1777	1284	463	1925	1462	505	1902	1397
4		394	1915	1521	386	1983	1597	-	-	-
5		763	1872	1109	723	1750	1027	612	1778	1166
6		652	1948	1296	634	1793	1159	701	1803	1102
7		458	2295	1837	387	2087	1700	571	2030	1459
8		695	2183	1488	-	-	-	666	2293	1627
9		738	2213	1475	743	2176	1433	699	2119	1420
10		491	2219	1728	496	2198	1702	458	2145	1587
	ã									
1		785	1270	485	661	1293	632	719	1240	521
2		693	1371	678	687	1379	692	-	-	-
3		706	1344	638	609	1306	697	655	1198	543
4		-	-	-	546	937	391	655	1135	408
5		773	1248	475	758	1296	538	746	1298	552
6		768	1527	759	760	1451	691	748	1479	731
7		564	1465	901	619	1439	523	633	1323	690
8		-	-	-	716	1087	371	848	1545	697
	õ									
1		607	782	175	661	818	157	597	920	323
2		411	817	406	438	907	469	-	-	-
3		489	931	442	476	900	424	536	943	407
4		479	782	308	354	795	441	453	824	371
5		626	923	297	570	871	301	583	844	261
6		664	1010	346	532	929	397	591	890	299
7		653	876	223	520	851	331	572	837	265
8		817	1048	231	792	1069	277	751	1114	363
9		770	1040	270	772	1017	245	680	1110	430
10		524	999	475	539	1185	646	484	1121	637
	ũ									
1		369	942	573	416	629	213	439	664	223
2		-	-	-	-	-	-	265	1130	865
4		271	849	578	256	974	718	-	-	-
6		455	1141	686	470	1022	552	530	833	303
7		457	791	334	316	739	423	293	882	589
8		437	1417	980	372	1366	994	546	1361	815
9		415	807	392	492	925	433	467	895	428
10		506	1520	1014	500	762	262	432	1203	771

Dangme2:Shai Speakers	Vowel	Token 1			Token 2			Token 3		
		F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
	i									
1		315	2513	2190	381	2463	2082	342	2404	2062
2		355	2479	2124	371	2478	2107	408	2524	2116
3		332	2151	1819	310	2287	1977	331	2224	1893
4		271	1898	1627	278	1915	1637	262	1919	1657
5		313	1806	1493	283	1717	1434	349	1884	1535
6		338	2544	2206	291	2553	2262	365	2527	2162
7		352	2113	1761	353	2167	1814	324	2129	1805
8		439	2081	1642	357	2179	1822	382	2180	1798
9		297	1789	1492	334	1784	1450	268	1779	1511
10		310	2339	2029	294	2463	2169	478	2403	1925
	e									
1		409	2250	1841	396	2207	1811	390	2223	1833
2		437	2358	1921	415	2369	1954	326	2497	2075
3		406	2077	1671	365	2000	1635	393	2106	1713
4		377	1709	1332	372	1673	1301	370	1748	1378
5		321	1695	1374	315	1495	1180	-	-	-
6		394	2337	1943	384	2268	1884	431	2399	1230
7		376	2163	1787	392	1990	1598	385	1919	1534
8		435	2025	1590	416	1996	1580	375	2031	1656
9		418	1606	1188	378	1701	1323	391	1703	1312
10		516	1990	1474	501	2059	1558	525	2059	1534
	ɛ									
1		590	2221	1631	585	2040	1455	577	2120	1543
2		614	1920	1306	560	2340	1780	550	2140	1590
3		592	1987	1395	594	1926	1332	537	1971	1434
4		546	1674	1128	530	1601	1071	528	1621	1093
5		485	1620	1135	576	1603	1027	488	1553	1065
7		529	1700	1171	565	1847	1282	499	1631	1132
8		581	1911	1330	536	1882	1346	590	1763	1173
9		542	1613	1071	533	1659	1126	489	1682	1193
10		726	1744	1018	682	1878	1196	694	1914	1220
	a									
1		-	-	-	805	1409	604	876	1607	731
2		997	1688	691	957	1724	767	842	1741	899
3		898	1434	536	894	1586	692	881	1510	629
4		773	1188	415	756	1219	463	739	1233	494
5		792	1381	589	715	1268	553	700	1313	613
6		926	1589	663	938	1628	690	963	1588	625
7		759	1413	654	764	1422	658	796	1404	608
8		0	0	0	771	1464	693	777	1319	542
9		730	1288	558	714	1280	566	720	1282	562
10		778	1708	940	937	1646	709	732	1660	928

Dangme2:Shai	Vowel	Token 1			Token 2			Token 3		
Speakers	ɔ	F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1		642	1016	374	601	1057	456	617	1014	397
2		613	1028	415	662	1060	398	523	1081	558
3		604	953	349	589	911	941	535	959	424
4		594	928	334	628	928	300	589	903	314
5		550	1068	518	551	1033	482	557	1060	503
6		752	1153	401	798	1126	328	786	1096	310
7		689	931	242	597	1017	420	654	994	340
8		611	1153	542	574	1104	530	603	1093	490
9		482	950	468	461	870	409	-	-	-
10		734	1234	500	752	1326	574	727	1236	509
	o									
1		-	-	-	442	996	554	411	896	485
2		437	1007	570	434	974	540	357	840	483
3		364	724	360	377	708	331	393	833	440
4		547	820	273	452	766	314	556	740	184
5		371	786	415	366	818	452	389	832	443
6		493	899	406	479	938	459	441	888	447
7		425	941	516	350	922	572	433	1060	627
8		427	884	457	416	945	529	376	919	543
9		347	902	555	341	859	518	333	782	449
10		523	1035	512	532	1103	571	552	1189	637
	u									
2		324	792	468	325	868	543	336	864	528
3		351	817	466	365	836	471	387	875	488
4		351	747	396	347	762	415	313	749	436
5		-	-	-	312	706	394	306	778	472
6		478	748	270	458	862	404	483	722	239
7		0	0	0	332	763	431	312	709	379
8		377	868	491	359	826	467	403	832	429
9		-	-	-	298	810	512	-	-	-
10		417	722	305	460	790	330	516	797	281
	ĩ									
1		-	-	-	321	2557	2236	-	-	-
2		365	2535	2170	407	2570	2163	359	2621	2262
3		393	2351	1958	372	2281	1909	324	2375	2051
7		382	2144	1762	357	2062	1705	403	2134	1731
9		458	1628	1170	523	1708	1185	539	1693	1154
10		459	2354	1895	481	2338	1857	320	2449	2129

Dangme2:Shai	Vowel	Token 1			Token 2			Token 3		
Speakers	ě	F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1		563	2132	1569	535	2140	1605	571	2223	1652
2		680	2075	1395	612	2182	1750	557	2138	1581
3		685	2143	1458	638	1960	1322	955	2053	1398
4		-	-	-	486	1905	1419	538	1800	1262
5		385	1718	1333	483	1663	1180	399	1730	1331
6		691	2287	1596	-	-	-	696	2204	1508
7		668	1781	1113	684	1786	1102	676	1815	1139
8		632	1845	1213	509	1811	1302	536	1830	1294
9		430	1668	1238	542	1679	1137	458	1624	1166
10		772	1868	1096	611	2006	1395	651	1796	1145
	ã									
1		660	1287	627	772	1502	730	717	1469	752
2		649	1315	666	899	1339	440	677	1286	609
3		844	1195	351	839	1176	1337	833	1321	488
4		641	1189	548	640	1152	512	624	1112	488
5		579	1176	597	527	1202	675	573	1184	611
6		940	1516	576	871	1493	622	887	1450	563
7		870	1327	457	837	1290	453	820	1252	432
8		785	1389	604	676	1483	807	796	1442	646
9		688	1147	459	520	1137	617	616	1129	513
10		-	-	-	-	-	-	782	1612	830
	õ									
1		712	1183	471	811	1216	405	779	1104	325
2		687	1120	433	688	1229	541	678	1100	422
3		0	0	0	635	996	361	581	956	375
4		589	774	185	557	971	414	565	834	290
5		523	741	218	434	736	302	401	826	425
6		765	1074	309	-	-	-	-	-	-
8		638	1039	401	628	894	266	563	829	266
9		612	1129	517	563	1117	554	505	902	397
10		596	1075	479	554	1099	545	508	1103	595
	ũ									
1		311	595	204	279	658	379	352	956	604
2		328	1056	728	322	965	643	0	0	0
3		354	987	633	0	0	0	352	753	601
4		416	720	304	383	712	329	-	-	-
5		-	-	-	-	-	-	324	739	415
6		499	940	441	465	1121	3656	494	1225	731
7		382	693	311	423	677	254	431	709	278
8		409	855	446	407	991	584	423	1000	577
10		471	936	465	425	880	908	-	-	-

Dangme3:Krobo Speakers	Vowel	Token 1			Token 2			Token 3		
		F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
	i									
1		317	2261	1944	321	1706	1385	274	2705	2431
2		400	2131	1731	331	2230	1899	393	2427	2034
3		379	1983	1604	391	1954	1563			
4		365	1942	1577	425	1991	1566	425	1861	1436
5		384	2370	1986	386	2444	2058	427	2584	2157
6		466	2285	1819	443	2252	1809	427	2297	1870
7		473	2120	1647	515	2269	1754	494	2285	1791
8		480	2415	1935	343	2422	2079	426	2650	2224
9		492	2457	1965	475	2404	1929	465	2370	1905
10		317	2425	2108	398	2458	2060	332	2471	2139
	e									
1		384	1740	1356	375	1840	1465	420	1938	1518
2		540	2099	1559	485	1965	1480	511	2018	1507
3		428	1801	1373	482	1796	1314	497	1873	1376
4		403	1861	1458	455	1870	1415	523	1861	1338
5		441	2082	1641	411	2173	1762	385	2200	1815
6		620	2126	1506	557	2164	1607	555	2135	1580
7		523	2027	1504	521	2060	1539	536	1967	1431
8		543	2270	1727	503	2261	1758	518	2307	1789
9		629	2188	1559	602	2199	1597	577	2273	1696
10		367	2291	1924	331	2368	2037	329	2288	1959
	ɛ									
1		511	1891	1380	496	1836	1340	461	1864	1403
2		746	2013	1267	746	1971	1225	702	1859	1157
3		504	1744	1240	507	1705	1198	509	1715	1196
4		516	1777	1261	525	1709	1184	519	1713	1194
5		622	2068	1446	594	2084	1490	556	2217	1661
6		857	1814	957	770	1973	1203	791	1980	1189
7		749	2015	1266	741	1976	1235	773	2017	1244
8		749	2235	1486	723	2193	1470	727	2161	1434
9		806	1909	1103	777	1800	1023	741	1843	1102
10		550	2173	1623	521	2096	1575	492	2152	1660
	a									
1		746	1531	785	732	1506	774	764	1383	619
2		831	1578	747	894	1548	654	798	1472	674
3		648	1261	613	675	1147	472	715	1263	548
4		782	1250	468	714	1232	518	699	1239	540
5		839	1574	735	805	1659	854	881	1674	793
6		852	1247	395	813	1266	453	869	1097	228
8		998	1723	725	840	1595	755	881	1742	861
9		0	0	0	936	1685	749	951	1747	796
10		780	1512	732	819	1450	631	819	1512	693

Dangme3:Krobo	Vowel	Token 1			Token 2			Token 3		
Speakers	ɔ	F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1		483	926	443	527	934	407	520	803	283
2		733	1174	441	745	1259	514	709	1115	406
3		499	849	350	503	949	446	493	890	397
4		491	836	345	583	936	353	506	826	320
5		632	1049	417	565	1018	453	570	1037	467
6		831	1127	296	770	1091	321	753	1154	401
7		683	1050	367	723	1212	489	738	1113	375
8		767	1293	526	729	1251	522	709	1225	516
9		874	1353	479	874	1370	496	813	1470	657
10		503	895	392	571	1006	435	567	907	340
	o									
1		385	783	398	337	787	450	387	826	439
2		483	980	497	577	942	365	530	938	408
3		414	957	543	457	897	440	503	900	397
4					538	840	302	472	747	275
5		469	961	492	438	840	402	423	855	432
6		573	803	230	550	816	266	551	944	393
7		552	1040	488	557	1061	504	545	1059	514
8		537	1079	542	529	1070	541	512	1032	520
9		633	1273	640	623	1223	600	616	1263	647
10		384	814	430	391	833	442	407	893	486
	u									
1		408	650	242	401	661	260	339	634	295
2		508	827	319	518	792	274	503	799	296
3		442	915	473	372	902	530	405	937	532
4		499	737	238	512	786	274	480	794	314
5		396	834	438	385	909	524	377	816	439
6		384	704	320	414	733	319	459	657	198
7		539	852	313	493	812	319	561	942	381
8		496	878	382	505	843	338	437	798	361
9					614	1050	436			
10		337	782	445	314	792	478	332	794	462
	ĩ									
1		567	2028	1461	387	2120	1733	431	1997	1566
3		311	2159	1848	315	2062	1747	404	1946	1542
4		450	2071	1621	476	1894	1418	414	2006	1592
6		422	2258	1836	495	2277	1782	497	2405	1908
7		474	2350	1876	0	0	0	502	2450	1948
8		504	2825	2321	499	2841	2342	523	2644	2121
9		518	2409	1891	499	2423	1924	490	2680	2190

10	350	2310	1960	382	2465	2083	413	2594	2181
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Dangme3:Krobo	Vowel	Token 1			Token 2			Token 3		
Speakers	ɛ	F1	F2	F2'	F1	F2	F2'	F1	F2	F2'
1		561	1874	1313	539	1956	1417	408	1819	1411
2		711	1875	1164	647	1907	1260	634	2161	1527
3		516	1749	1233	571	1864	1293	514	1868	1354
4		463	1840	1377	623	1924	1301	622	1950	1328
5		590	2210	1620	604	2221	1617	586	2172	1586
6		771	1952	1181				722	2157	1435
7		712	2300	1588	705	2137	1432	621	2198	1577
8		788	2299	1511	746	2342	1598	768	2341	1573
9		683	2253	1570	746	2224	1478	721	2187	1466
10		574	2179	1605	601	2200	1599	666	2089	1423
	ǎ									
1		723	1340	617	696	1330	634	644	1216	572
2		703	1421	718	670	1386	716	651	1279	628
3		683	1208	525	617	1305	688	650	1320	670
4		662	1134	472	793	1176	383	762	1115	353
5		694	1443	749	695	1249	554	681	1437	756
6		812	1472	660	700	1671	971	821	1576	755
7		629	1269	640	657	1212	555	767	1264	497
9		943	1383	440				930	1366	436
10		799	1348	549	907	1371	464	794	1443	649
	õ									
1		535	859	324	533	897	364	598	907	309
2		643	980	337	683	965	282	583	900	317
3		587	746	159	541	758	217	574	848	274
4		583	785	202	569	963	394	592	868	276
5		608	952	344	558	886	328	598	849	251
6		775	1168	393	740	1028	288	754	1075	321
7					605	1038	433	584	1115	531
8					834	1182	348			
9		746	1133	387	669	957	288	797	1253	456
10		665	948	283	678	933	255	618	904	286
	ũ									
2		515	1010	495	447	953	506	445	933	488
3		371	876	505				365	1297	719
4		502	1117	615	519	1341	822			
5		410	794	384	426	741	315	417	671	254
6		592	1420	828				511	881	370
7		509	1105	596	530	1101	571	507	1110	603
10		494	1124	630	510	1032	522	425	1156	731